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## David Bedell Pickering
### 1873-1946

By LEON CAMPBELL

Even for one who had the good fortune to know David Bedell Pickering as an amateur astronomer over the last thirty years, it is not too easy to write of his life; he was so versatile and had so many accomplishments. He was a man of such outstanding personality that his mere presence in any gathering was an inspiration to one and all.

Although born in Elmira, New York, on January 18, 1873, he could well claim New Jersey as his home state, for it was there that he went to live at the age of six months with his parents. His earliest years were spent in Newark, and his later years in East Orange. Descended from a long line of Pickerings who originally came from Pickering, England, he could trace his lineage to a branch which descended from a nephew of Timothy Pickering who had settled in Salem, Massachusetts. His grandfather was Dan Pickering, once postmaster of Elmira

DAVID BEDELL PICKERING
1873 - 1946

during and following the Civil War. His father was Silas Wright Pickering, who at the age of 13 ran away to fight in the Civil War, but who was soon brought home to aid in the distribution of mail to Confederate prisoners who were then in prison camps in that locality. Silas lived to the ripe old age of 87. David's mother was Annie E. Bedell, who died when the boy was only 15 years old.

"Dave," as he was so familiarily known to one and all, graduated from the Newark Academy at the age of 16. While at school he was not only an apt student, but excelled in sports as well, especially in track events, including the high jump. He retained his agility till well past middle life, as evidenced by his ability to walk on his hands and to perform on various types of gymnastic apparatus.

From early boyhood he loved music. He could play the violin, as he said, passably well, and for many years he sang in church choirs in Newark, where, incidentally, he met his future wife, Lillian Sayre, the mother of his five sons, including two sets of twins. With his own fine baritone and the equally good contralto voice of Mrs. Pickering, their home frequently rang with the cheer of song-fests, greatly enjoyed by the whole family.

By profession Pickering could be called a jeweler, starting in at the diamond trading business, and later joining the jewelry firm of Whiteside and Blank of Newark, which later became Henry Blank & Co. He served as vice-president of the firm for many years, and even after his retirement in the early twenties, he remaind as a director until January of this year.

He was always keenly interested in the stars, and from an early age enjoyed the pleasures of a telescope, starting with a small marine glass, graduating to a 3½-inch refractor later, and eventually securing a 5-inch Tolles instrument. These last two instruments were in turn mounted in a dome atop his home, where much pleasure was given to visitors, and where most of his variable star observing was carried on.

It was in 1914 that Dave made his initial contact with fellow amateur astronomers, and when he first became an active variable star observer, making his original observation on the ever popular star, SS Cygni, in August of that year. From the start he was a moving spirit in the American Association of Variable Star Observers, not only as an ardent observer, but also as an organizer. He played an important role in the formal organization of the Association, and served as its first president in 1917, and again in the same capacity in 1928.

An accomplished penman and artist-designer, it is to Pickering that the A.A.V.S.O. is so greatly indebted for putting its observing charts on an improved working basis. He devised the whole present system of chart making, and for many years acted as chairman of the Chart Committee. The initials D.B.P. still adorn many of the original blueprint charts and attest his skill and energy.

Preceding the First World War, the home of the Pickerings in East Orange was the scene of more than one A.A.V.S.O. Spring Meeting. Literally dozens of its members journeyed there, to be most hospitably entertained, and it is still surprising to recall how and where so many guests were "put-up" in their home. Their own boys were doubtless "farmed-out," but nevertheless no one who remained ever went "bedless to bed."

Music and the stars were not Dave's only hobbies. He was an expert at photography, not only in the snapping of the scenes, but also in the printing and enlarging of them. Many an A.A.V.S.O. member's home is adorned with souvenirs of his artistic skill, not only in the form of original Christmas greetings, but with views of Holland, Italy, and other countries.

Those who have read Dave's inimitable accounts of his travels in this country and abroad under the title "The Astronomical Fraternity of the World" will recall his remarkable facility with the pen, describing his journeys and his meetings with astronomers, both professional and amateur. His numerous contributions to *Variable Comments* are gems of literary talent, mixed with keen wit and good humor. He proudly boasted that he was the brother of the famous poetess who wrote under the pen name of Theodosia Garrison. He could well have boasted of real talent along this line himself.

He was a man of tremendous energy, both physical and mental. He could recite verse after verse of the world's best writers, and it was a common pastime with him and his family to indulge in games which involved a knowledge of poetry and general information, which, as one of the boys once wrote, "did us all not a bit of harm."

At the age of sixty, Pickering decided to devote his energies to art with the brush, and, as with everything else which he attempted, he became a real artist. Many of his paintings, in both water color and oils, have been exhibited in the salons of his own and neighboring cities.

One of Dave's other hobbies was the culinary art. Being obliged for a number of years to partake of specially prepared meals, he practiced the art, not only for his own benefit, but eventually for the whole family.

Pickering's ability as an amateur astronomer was well recognized by the professional. He was an accomplished and dynamic lecturer, both on the platform and over the radio, and his ability was rewarded by election to several astronomical societies of the world. Besides membership in the A.A.V.S.O., he was a member of the American Astronomical Society, the Royal Astronomical Society of England, and the Société Astronomique de France. He also served for many years on the Variable Star Commission of the International Astronomical Union, attending several of its meetings in this country and abroad. He also served as a member of the Harvard Observatory Visiting Committee.

In 1938 he received the Fifth Merit Award of the A.A.V.S.O. for his

long continued interest in the Association. For a number of years he sponsored the A.A.V.S.O. award of medals for the original discoveries of novae by visual methods.

In April of this year he and Mrs. Pickering celebrated their fiftieth wedding anniversary, and this was the last occasion on which he was able to meet with his family, including his five sons and their wives, and seven grandchildren. He died on June 13, after a long suffering illness. Through all his illness he took a most philosophical view of the situation, realizing that his life had been quite full and complete, and one in which he had attained some degree of happiness and success. The "House that Pi Built" still stands, even though "Pi" himself is no longer at its head.

To have met and known Dave Pickering would be a distinction in anyone's life.

AUGUST 21, 1946.

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# Telescopes, Stars, and Atoms*

By SIR HAROLD SPENCER JONES†

Research in many branches of science, and particularly in atomic physics, was greatly speeded up during the war; but research in astronomy was largely if not entirely suspended. Now, when astronomers are returning to their telescopes and the resumption of international co-operation is possible, is a convenient time to take stock of the present position and to plan for the future.

In observational astronomy England has a proud record; it is regrettable that she has dropped out of the vanguard of progress. The reason is not far to seek; it is the failure to equip our observatories with powerful modern instruments. There is no telescope in Great Britain with an aperture larger than 36 inches. Contrast this with America's telescopes—eight with apertures of from 60 to 100 inches, and a 200-inch instrument nearly completed! Small telescopes are adequate for some purposes but they cannot compete with large telescopes in most types of observation; where great light-gathering power is essential they cannot be used at all. It is true that our somewhat unfavorable climate would not warrant the very high cost of a 200-inch telescope; but telescopes of apertures of, say, from 60 inches to 80 inches, at sites selected for the best attainable atmospheric conditions could undoubtedly be justified.

## MOVING FROM GREENWICH

As some excuse for this state of affairs it should be mentioned that the progressive deterioration during the past fifty years in opportunities

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for astronomical observations at the Royal Observatory, Greenwich, caused by pollution of the atmosphere and brightness of the sky at night, consequent upon the growth of London, would not have justified the installation of telescopes of great light-grasp there. The decision to move the Observatory from Greenwich to Hurstmonceux in Sussex —a site selected because of the favorable conditions for observations— will give relief from the distressing handicaps under which it has labored for so long. The provision of a large modern telescope would enable the Royal Observatory to continue to play a prominent part, as it has done in the past, in the advancement of astronomy.

The needs of the smaller observatories in Great Britain, with their moderate staffs, could best be met by the establishment of a common observing station, equipped with a large telescope, where each observatory could carry out its own special research programs. Such a scheme is under consideration; if it can be carried through it will prove a great stimulus to observational astronomy in Great Britain.

Many other countries in Europe are faced with similar difficulties, but with the added one that out of their limited resources they cannot afford to purchase or construct a large telescope. At a recent meeting in Copenhagen of delegates of the International Astronomical Union there was a discussion of the need for a well-equipped international observatory, which should be available for use by properly qualified and accredited astronomers from all countries. The delegates from every country represented were unanimously in favor of the idea; it was considered that the United Nations Educational Scientific and Cultural Organization might appropriately sponsor such a scheme, and the question is to be discussed with this body.

## High Altitudes

At the same meeting a special commission was appointed to consider the question of interchange of astronomers. One large telescope may be particularly well adapted to one type of observation; another telescope, of different design, to another type of observation. It is now possible, for instance, by the use of a specially designed apparatus, to observe the sun's corona at a high altitude station, without waiting for the rare occasions of a total eclipse of the sun.

By the free interchange of astronomers between observatories, enabling the most suitable instruments to be used on particular research programs, the limitations of equipment and of climatic conditions to which many observatories are handicapped would be to some extent removed. In the United States, astronomers from some of the smaller observatories make fairly regular visits to one or other of the great mountain observatories and obtain data which are investigated and discussed on return to their own observatories. Such co-operation has yielded rich results.

Work on the 200-inch mirror for the great telescope on Mount Palomar was stopped when the United States entered the war, but has now been resumed. It is impossible to forecast with any accuracy how long it will be before the mirror is completed and the telescope brought into use; two years may be needed. This telescope will be able to probe space to a distance of about one thousand million light-years and will greatly extend the present limits of observation; it will add considerably to the knowledge of remote galaxies and will provide information bearing on the question of the expansion of the universe. The more detailed study which it will permit of the brighter stars will provide new information on many problems.

It now seems probable, in fact, that more important additions to knowledge may come from the detailed study of selected stars, particularly those showing peculiarities in their behaviour or in their spectra, than from mass surveys. Why, for instance, should one particular star have an abundance of isotope 13 of carbon far in excess of its abundance in the earth or in the average star? It was the faint companion of Sirius which provided proof of the existence of "dense matter," with a density exceeding 50,000 times that of water.

The sun is the star which can be studied in the most minute detail, and it continues to present many problems which are as yet unsolved. The cause of the enormous increase, of the order of ten-thousand-fold in the electro-magnetic radiation of a few meters wave-length from the sun, at the times when a bright eruption or flare occurs on the sun's surface, is unknown. In the sun's corona, again, are atoms of iron and nickel from which many of their electrons have been stripped; such stripping might be expected to occur at a temperature of one million degrees or more, yet the sun's temperature is only about 6,000 degrees. There is no clue at present to an explanation.

## The Sun's Energy

The astronomer is able to study matter under conditions of temperature, pressure, and density which are not available to the physicist, and is thereby able to supplement the information which can be obtained from laboratory investigations. Consideration of the energy radiated by the sun and stars, in conjunction with certain conclusions reached about the age of the stars, proved that their radiation was maintained by the utilization of atomic energy and enabled some fairly definite conclusions to be arrived at concerning the way in which this energy is released. The atomic bomb, in releasing atomic energy uses essentially the power that runs the universe. This is an overall balance between the energy released within a star and the energy radiated by the star. But why is the energy radiated by some stars, including the sun, constant or nearly constant, while that radiated by other stars is widely variable? Astronomy is likely to have a good deal to say about questions of atomic energy.

# The Training of the Eye for Astronomical Observing

By WALTER H. HAAS

Many well-known lunar and planetary observers have pointed out that an experienced observer sees more detail on the moon or on a planet than does a novice. This matter has been stressed by Denning,[1] Douglass,[2] Hamilton,[3] Fauth,[4] and others; indeed, this advantage of experience has not, to my knowledge, been denied by anyone capable of judging. Recently H. M. Johnson has clearly presented the same argument and has published drawings which illustrate how his eye gained skill on one planet.[5]

My own observational experience consists of probably about 5,000 hours spent at the telescope in the systematic study of the moon and the planets over a period of 11 years. Apertures used range from 4 to 18 inches; and both refractors and reflectors have been employed, some of them of unusually good quality.

A complete discussion of how the eye is trained and a proper treatment of all the physiological and psychological factors involved is outside the scope of this paper. There can be no doubt that what has once been seen is later seen more easily; a small lunar crater that I first perceived with an 18-inch telescope has since been remarked with two 4-inch telescopes (though far less clearly). Moreover, it has been suggested that one learns with practice to utilize the moments of best seeing and to perceive then features hidden in the ordinary poorer seeing. Not denying that these matters and still others play a rôle, I should like to suggest that to a large extent the training of the eye is *its conditioning to the brightness of the telescopic image* and that, as it so adapts itself, the eye *learns to distinguish slighter contrasts of tone* on an extended surface. All lunar and planetary details are really only such contrasts.

The *great importance of contrast* in visual lunar and planetary studies is not sufficiently realized and can perhaps be best appreciated by observing Mercury. On a mid-afternoon sky this planet is too pale with an ordinary telescope to show much detail. As the sky darkens near sunset the features grow more distinct. As twilight deepens and Mercury grows yet brighter, the markings grow less easy to see and are finally lost in glare. Similar effects are found with other planets.

I offer these considerations in support of the explanation suggested above:

1. When I began to observe with an 18-inch telescope after having used a 6-inch for the several preceding months and without having previously used any aperture above 12 inches, my ability to see detail

showed a definite progressive improvement over a period of months *as though the eye were being retrained.* There had been a similar improvement during the first year and a half of observing. Since fairly comparable magnifications were used, the large telescope gave brighter images than the smaller instruments had. Was not the eye adapting itself to *brighter* telescopic images much as it had previously adapted itself to bright telescopic images?

2. I have usually used the right eye for observing and have now noticed for some years that this eye adjusts itself more quickly to the telescopic image than does the left eye, an effect especially noticeable on the full moon. There the left eye not only takes much longer to see the same things than the right eye needs (as on planets also), but in addition finds the image painfully bright, much as *non-observers* do. Johnson has similarly found the eye usually used at the telescope superior to the other.[5] It is obvious that psychological influences and foreknowledge of detail cannot explain differences between the two eyes. The fact that one eye can become dark-adapted for seeing in very low illumination while the other eye is used in ordinary illumination[6] shows the existence of induced physiological differences between the two eyes. It appears significant that when I examine the moon with an unaided eye, the left eye does *not* give the effect of greater brightness and less sharpness relative to the right eye, as in the telescope. Moreover, I can see Alcor and can separate $\alpha_1$ and $\alpha_2$ Capricorni equally well with either naked eye, strongly suggesting an initial lack of telescopic differentiation.

3. It has been authoritatively stated that a trained eye perceives degrees of contrast one-third as great on a surface of specified brightness as an average eye can distinguish.[7]

4. It appears very probable that the eye gains skill only on the class of objects to which a specializing observer gives chief attention and remains untrained on objects of greatly differing brightness. I have failed to resolve double stars which are clearly separate to S. G. Barton, who observes principally these stars; and I probably cannot see as faint stars as experienced variable-star workers can. When looking at planets with observers who study chiefly other objects, I have learned from conversation that they apparently see less than I do.

5. Denning urged observers to imitate him in using one eye for bright planets and the other for faint stars and satellites, asserting that he thereby got better results on both kinds of objects.[1] He also advised those especially interested in dim objects to avoid watching bright ones.[1] This energetic observer clearly thought that either eye could be conditioned to objects of a given brightness.

6. Upon beginning to observe Saturn very regularly after six years of comparatively casual work, I fairly soon discovered two previously unnoticed *faint* belts, much as if with more practice the eye had adapt-

ed itself better to the Saturnian image. The same telescope was being employed as in the two preceding years.

7. When I occasionally used a 6-inch reflector while employing chiefly an 18-inch refractor, I felt handicapped by the dimness of the image in the small telescope; and I do not think that I saw as much detail with this instrument as when it had been previously regularly used.

8. In so far as telescopic vision is rod-vision, it is necessarily dependent upon contrasts only; and military experience has emphasized the harmful effects of such contrast-reducing factors as dirt or scratches on goggles and glare from optical or plastic surfaces.[6]

The interested reader can easily devise experiments to test the above explanation of how the eye is trained. It appears necessary to take observers previously totally inexperienced and to continue whatever tests are made for many months. Particularly critical points for the explanation in question are the effect of large changes in the aperture of the telescope used or in anything else that would greatly change the brightness of the telescopic image and possible induced differences between the two eyes.

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# The Development of Astronomical Photometry

By HAROLD F. WEAVER

*(Continued from page 404)*

## PERIOD IV

Chronologically, the fourth period of astronomical photometry is older than the third period. This fourth period, marked by the use of physical instruments to measure radiation from celestial objects, may properly be said to have begun with the first thermometric measurements of solar energy. In 1800, for example, Sir William Herschel[111] observed

[111] *Phil. Trans.*, **90**, 284, 1800. An interesting account of early investigations in this field is contained in *Ann. Smith. Inst. Astrophys. Obs.*, **1**, 1900.

that a thermometer exposed to the solar spectrum continued to exhibit heating effects beyond the limit of visible radiations, and concluded that at least one-half of the heat from the sun was invisible, and, as he believed, had no connection with the visible radiations from the sun.[112] From a practical point of view, however, the fourth period may be said to have begun with the solar researches initiated by Langley and his contemporaries, shortly before the opening of the modern period of photographic photometry.

## The Instruments of the Fourth Period

The physical instruments of the fourth photometric period can be divided into groups in several ways. They can, for example, be divided into non-selective[113] or selective[114] receivers, in which classes we can place, respectively, the pyrheliometer, bolometer, thermoelements, radiomicrometer, and radiometer (non-selective), and the photocell (selective).

Again, these instruments can be divided into three groups on the basis of their sensitivity. In the first group of instruments, the least sensitive, of use in the measurement of the total solar radiation, we can place the pyrheliometer. In the second group of instruments of intermediate sensitivity we can place the bolometer, the various thermoelements, the radiomicrometer, and the radiometer, instruments of use in the measurement of the energy distribution in the solar spectrum, and, when used in conjunction with large telescopes, of use in the measurement of the total radiation and in the spectrophotometry of the planets and the brighter stars. Finally, in the third group we can place the photocells, instruments of the highest sensitivity which can be used for measuring the brightness of the faint stars, nebulae, clusters, and so forth. These various instruments may be conveniently discussed according to this latter division.

*The Non-selective Instruments of Least Sensitivity.* The instruments used for the observation of the total radiation of the sun, primarily in conjunction with the determination of the solar constant, can be divided into two groups: primary instruments with which the total amount of

[112] The curious belief that heat and light were separate entities was rather widespread during the first half of the nineteenth century. It was opposed by Melloni in 1843 who stated correctly that light was "merely a series of calorific indications sensible to organs of sight, and *vice versa* the radiations of obscure heat are veritable radiations of light."

[113] A non-selective receiver is one which responds to radiant energy of all wave lengths. The magnitude of this response to radiant energy of wave length $\lambda$ is proportional to the amount of radiant energy of wave length $\lambda$ falling upon the receiver. Unfortunately, we have no absolutely non-selective receivers, although those which will be discussed in this section do approach the ideal instrument over most of the wave-length range of interest.

[114] A selective receiver is one which does not respond to each wave length of radiant energy in proportion to the amount of radiant energy of the wave length under consideration falling upon the receiver.

radiant energy falling on a given area can be determined in absolute units; secondary instruments (sometimes called actinometers) which ordinarily must be calibrated by comparison with a primary instrument in order to yield radiation measurements in absolute units.

Many forms of apparatus for measuring the solar radiation have been devised since the first instrument for that purpose was constructed by Pouillet in 1828. All devices have had the common feature, however, that the radiation to be measured falls upon a blackened absorbing surface behind or within which is situated a thermometer or other temperature indicator, whose readings form a principal part of the record. Three general methods of reading these devices have been used: 1. In a body of measured heat capacity the rate of rise of temperature due to the absorption of radiation is noted, and the gain or loss of heat to the surroundings is allowed for by cooling corrections immediately before and after exposure to the sun. 2. In a body of measured heat capacity the rate of rise of temperature due to absorption of radiation is observed, together with data assumed to indicate what rate of rise corresponds to the state when the body neither gains nor loses heat to the surroundings. 3. Two bodies of similar form are heated, one by absorption of solar radiation, the other by a standard source of heat, or one body is heated at one time by solar radiation and immediately thereafter by a standard heat source. Means are provided to indicate when corresponding parts of the surfaces of the two bodies are equal, or when the single body has reached the same temperature at the two times. When this equality has been attained, the rate of heating by the absorbed solar radiation is assumed to be equal in amount to that introduced by the standard source.

The important primary instruments[115] are based upon the third principle. The earliest of these primary instruments, the so-called Ångström compensation pyrheliometer, designed by K. Ångström[116] in 1893, consisted essentially of two identical platinum or manganin strips one of which was warmed by solar radiation. The other, carefully shielded from sunlight, was warmed by a variable measurable electric current, which was adjusted so that the temperatures of the two strips, indicated by a built-in thermocouple, were identical. When so adjusted, the energy supplied in the form of electric current was assumed to be

[115] Only a brief outline of a few of the more important instruments can be given here. For a more complete discussion of pyrheliometers, which go back in time as far as Pouillet's instrument of 1828, the reader is referred to "Handbuch der Astrophysik" I/1, 420 ff., and "Handbuch der Experimentalphysik," **26**, 798 ff., and to the original papers which will be found listed in these references. Accounts and bibliographies of the other instruments of the fourth photometric period will also be found in these references.

[116] *Phy. Rev.*, **1**, 365, 1893.

equal[117] to the solar energy received by the first strip, the area of which was known.

Advances in the design of absolute instruments were made in 1903 and the years following by Abbot[118] and the other observers of the Smithsonian Astrophysical Observatory with the introduction of the water-flow-pyrheliometer. In the final form of this instrument a blackened receiver cavity of aperture limited by a diaphragm was surrounded by a jacket through which water flowed at constant velocity. The difference of temperature of the water at its points of entrance and exit was measured by means of thermoelements, and was subsequently duplicated by electrical heating of a coil in the receiver cavity. The electrical energy needed to reproduce this solar heating was taken as a measure of the amount of solar energy falling on an area equal to that of the diaphragm admitting sunlight to the pyrheliometer.

In 1913 a modification of this basic type of instrument was introduced as the water-stir-pyrheliometer[119] in which the blackened receiving cavity was surrounded by a jacket containing a fixed amount of water kept in constant motion by a stirring mechanism. The temperature taken up by the water after exposure of the cavity to sunlight, was, as before, duplicated by means of a heating coil, the energy required to accomplish this being, once more, a measure of the solar energy incident upon the surface of the receiver.

Both these instruments have been improved by making them twin devices measuring purely differentially. Shulgin,[120] and Abbot and Aldrich[121] have made a revised water-flow-pyrheliometer consisting of two independent insulated adjacent units operating simultaneously from the same source of water. While one is warmed by solar radiation the other is warmed by an electric current. When one measurement has been completed, the methods of warming are interchanged and the measurements repeated. In this manner variations of water velocity and temperature are well eliminated. A complete analogous water-stir-pyrheliometer has been devised by Tingwaldt.[122]

The most commonly used secondary instrument, the silver-disc pyrheliometer, works on the calorimeter principle. Sunlight falling on a silver disc causes the mercury in a thermometer in thermal contact with the silver disc to rise and hence to furnish readings proportional to the intensity of radiation of the sun. This instrument is used generally only to make relative measurements, and does not yield values

[117] Later examination has shown that this is not strictly true because of edge effects and the differences in the methods of heating the two strips. These errors can be allowed for.

[118] *Ann. Astrophys. Obs. Smithsonian Inst.*, **2**, 39, 1908; **3**, 52, 1913.

[119] C. G. Abbot, *Ann. Astrophys. Obs. Smithsonian Inst.*, **3**, 64, 1913.

[120] *M. Weather Rev.*, Aug., 1927.

[121] *Smithsonian Misc. Coll.*, **87**, No. 15, 1932.

[122] *Zeitschr. f. Instrkde.*, **51**, 593, 1931.

in heat units unless calibrated, preferably by comparison with an absolute pyrheliometer.[123]

*The Non-selective Instruments of Intermediate Sensitivity.* The bolometer, one of the instruments of the second group of energy measuring devices, was invented and first used in an astronomical application by Langley[124] in 1880. It consisted of two nearly identical thin strips of metal (generally platinum), which were blackened on one side and which formed two arms of a Wheatstone bridge. One strip was carefully protected from radiation, the other was exposed to the radiation to be measured. The energy absorbed by the exposed strip warmed it, increased its resistance, destroyed the balance of the bridge, and caused a galvanometer to deflect, thus giving a measure of the amount of radiant energy falling on the strip. The design of Langley's original instrument has been considerably improved by subsequent investigators, notably Abbot, who placed the bolometer in a glass case at an atmospheric pressure of $10^{-3}$ mm of mercury, and in this manner increased its sensitivity by a factor of nearly ten.

The first astronomical application of the bolometer was in the measurement of the energy distribution in the solar spectrum, and its primary usefulness has remained in that field; it is used in conjunction with a prism spectrograph in the routine determination of the solar constant. This so-called spectrobolograph gives the relative energy distribution in the solar spectrum while a pyrheliometer used at the same

[123] Devices related to the pyrheliometer and used for the measurement of sky and nocturnal radiation (by which is meant the loss of thermal radiation from terrestial objects to space) have been described by Ångström, and by Abbot and Aldrich. Ångström's device, known as the pyrgeometer (K. Ångström, *Smithsonian Misc. Coll.*, **65**, No. 3, p. 28, 1915), consisted of a modified compensated pyrheliometer having one polished strip and one blackened strip. On exposure to space, the dark strip cooled more quickly than the light strip. By heating the dark strip electrically to the temperature of bright strip, a measure of the nocturnal radiation was obtained. Modifications of this instrument have been made. (K. Ångström, *M. Weather Rev.*, **47**, 769, 1919.)

The pyranometer, a device primarily for the measurement of the amount of radiation received from the sky, was constructed by Abbot and Aldrich (*Smithsonian Misc. Coll.*, **66**, Nos. 7 and 11, 1916), and consisted essentially of two short strips of blackened manganin suitably mounted in the center of a polished nickel-plated ring of copper. One strip was ten times as thick as the other, and hence on exposure to radiation the temperature rise in the thick strip was less than that in the thin strip because of its greater thermal conductivity. This temperature difference was indicated by thermojunctions attached to the backs of the strips and connected to a galvanometer. After being exposed to radiation from the sky as indicated, the strips were shaded and the galvanometer deflection caused by sky radiation was reproduced by electrical heating. The energy required to achieve this heating was taken as a measure of the energy received from the sky. During this entire procedure the strips were covered with an optically figured, hollow, hemispherical screen of ultraviolet crown glass which admitted direct or scattered solar radiation from the sky, but which prevented the exchange of long wave-length radiation between the strips and the sky. If the hemisphere were removed, the device was useful for measuring the outgoing or nocturnal radiation.

[124] *Proc. Amer. Acad. Arts and Sci.*, **16**, 342, 1881.

time records the total energy received from the sun, and hence serves as a means of calibrating the bolograph records. The bolometer, again in the form of a spectrobolograph, has been used to determine the energy distribution (at specified wave lengths) along a diameter across the face of the sun, and for a determination of the ratio of radiant energy received from sunspots to that of the general solar surface. Likewise the bolometer has been used to observe the intensity of radiation in the solar corona, and also, in a particularly sensitive form, a bolometer has been used in connection with the 100-inch reflector at Mount Wilson to determine the energy distribution in the spectra of a few of the brightest stars. The results obtained with a bolometer in this latter type of work did not prove to be satisfactory, however, and more efficient methods of determining the energy distribution in the spectra of the stars were soon suggested and tried.

The non-selective physical instruments which have found the greatest application in the measurement of the radiant energy of the stars and planets are the thermocouple and the radiometer. To a much smaller degree the radiomicrometer has also been used in such observations.

The thermoelectric effect, upon which the thermoelement is based, was discovered in 1825 by Seebeck, who found that if a closed circuit were constructed of two or more different kinds of metallic wires[125] a current would in general flow around the circuit if the junctions of the dissimilar metals were maintained at different temperatures. This effect was soon made use of in the construction of the thermopile, a collection or a group of thermocouples or junctions of dissimilar metals working together, for the measurement of radiant energy.

The radiomicrometer, an adaptation of a thermoelement made independently, apparently, by d'Arsonval[126] and Boys[127] at almost the same time for the purpose of measuring the radiation of the moon and stars, was essentially a moving-coil galvanometer of the d'Arsonval type in which the coil consisted of a single loop made of two dissimilar metals which formed a thermocouple. The thermojunction appeared at the bottom of the coil, where it could conveniently be irradiated with the radiant energy to be measured. The instrument never proved to be of particular value in astronomical applications.

Among the earliest attempts to apply thermoelements to the measurements of stellar radiation may be mentioned the observations of Sirius, Pollux, Regulus, and Arcturus made by Huggins[128] in 1868 with two pairs of bismuth-antimony thermoelements in the focus of an eight-inch reflector, and similar measurements made by Arcturus and Vega by

[125] Seebeck originally used antimony and bismuth wires.

[126] *Soc. Fran. Phys.*, **30**, 1886.

[127] *Proc. Roy. Soc. London*, **42**, 189, 1887; **44**, 96, 1888; **47**, 480, 1890; *Phil. Trans.* **180A**, 169, 1889.

[128] *Proc. Roy. Soc. London*, **17**, 309, 1868-69.

Stone[129] in 1869 with a 12¾-inch refractor. The times required to obtain readings in these early experiments were very long, of the order of five to ten minutes, and the deflections were very small. While the results were said to be fairly reliable, the instruments involved were entirely impractical from the point of view of using them for routine observations of the "total" radiation from the stars.

In 1910 pliable bismuth wire became available commercially, and considerable advances were made in the art of thermocouple construction. At about that same time interest was stimulated by the publication of several important theoretical papers on thermoelements, one of them by Johansen[130] relating to the design of thermopiles for measuring radiant energy.

In 1913 Pfund,[131] employing a vacuum thermocouple of his own construction used in conjunction with the 30-inch reflector at the Allegheny Observatory, made thermoelectric measurements of Vega, Jupiter, and Altair. With Pfund's thermocouple, deflections were obtained in a matter of a few seconds as compared to the minutes required to obtain deflections with former thermoelements, and the practicability of measuring the "total" energy of at least the brighter stars was demonstrated.

In 1914 Coblentz,[132] working with the 36-inch Crossley reflector at the Lick Observatory and very sensitive vacuum thermocouples which he had constructed, made the first extensive series of thermoelectric observations of the "total" radiation of 125 celestial objects among which were included 110 stars, some of these being as faint as visual magnitude 6.7. In addition to making measurements of the total stellar radiation, Coblentz also made what were essentially crude spectrophotometric measurements for a number of the stars. He did this by determining for the object under examination the ratio of the total amount of energy recorded with and without a water cell[133] placed before the thermocouple. With the cell in place, radiation lying in the wave-length range 0.3 $\mu$ (atmospheric cut-off) to 1.4 $\mu$ were observed; without the cell, radiations within the range 0.3 $\mu$ to the transmission limit of the thermocouple cell far in the infrared were measured.

By means of such water-cell transmission measurements, the first of their kind, Coblentz showed that, of the total radiation emitted, blue stars have about twice as high a percentage of visible radiation as yellow stars, and about three times as high a percentage of visible radiation as red stars.

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[129] *Proc. Roy. Soc. London*, **18**, 159, 1869-70.

[130] *Ann. d. Physik* (4), **33**, 517, 1910; *Phys. Zeitschr.*, **14**, 998, 1913.

[131] *Pub. of the Allegheny Obs.*, **3**, 43, 1913.

[132] *L. O. B.*, **8**, 104, 1915. The thermocouples used were of several types and will be found described in Coblentz's original paper.

[133] This cell was one cm thick. The windows through which the radiation passed were made of quartz. Laboratory measurements showed that this cell transmitted only those radiations of wave lengths shorter than 1.4 $\mu$.

In 1921 Coblentz[134] made further thermoelectric measurements with the 40-inch reflector at the Lowell Observatory, where he investigated (among other things) the feasibility of obtaining the spectral energy distribution of stars by means of filters used either singly or in combination. The general method, an extension of the previous water-cell procedure, was entirely analogous to that followed by Nordmann with his heterochrome photometer as discussed among the instruments of the second period. The filters used by Coblentz were:

Fluorite: (the window of the vacuum chamber) transmitted extreme ultraviolet to 10 $\mu$.

Quartz: thickness 4.77 mm transmitted extreme ultraviolet to 4.1 $\mu$.

Watercell: thickness 1 cm (thin quartz windows) transmitted extreme ultraviolet to 1.4 $\mu$.

Yellow glass: Schott Jena 5560, thickness 2.97 mm transmitted 0.43 $\mu$ to 4 $\mu$.

Red glass: Schott Jena 4512, thickness 1.97 mm transmitted 0.6 $\mu$ to 4 $\mu$.

Pyrex glass: thickness 1.19 mm transmitted violet to 2.8 $\mu$.

Blue-purple glass: Corning G 585, thickness 3.15 mm transmission complex. Mainly of interest for transmission in two narrow bands 0.3 $\mu$ - 0.4 $\mu$ and 0.6 $\mu$ - 1.2 $\mu$.

By means of these filters it was possible to isolate spectral regions in the ranges 0.3 $\mu$ to 0.43 $\mu$, 0.43 $\mu$ to 0.60 $\mu$, 0.60 $\mu$ to 1.4 $\mu$, 1.4 $\mu$ to 4.1 $\mu$, and 4.1 $\mu$ to 10 $\mu$.[135]

With these filters Coblentz measured the energy distribution in the spectra of a number of stars and determined their temperatures through comparison of the observed energy distributions with theoretical blackbody radiation curves.

During the years 1922 and 1924, fairly extensive series of measurements of planetary temperatures were made by Coblentz and Lampland[136] at the Lowell Observatory by means of filter spectrophotometry. A somewhat smaller set of filters than previously used, and consisting of transmission screens of water, quartz, glass, and fluorite afforded a separation of the radiation of the planets into spectral regions of 0.3 $\mu$ to 1.4 $\mu$, 1.4 $\mu$ to 4.1 $\mu$, 4.1 $\mu$ to 8 $\mu$, 8 $\mu$ to 12.5 $\mu$, and 12.5 $\mu$ to 15 $\mu$. The window in the thermocouple cell was of rock salt and hence transmitted the far infrared. The principle involved in these measurements was that the radiation observed from any planet could be separated into two spectral energy distribution curves: one that of sunlight reflected from the planet's atmosphere or surface, and the other that of the planetary radiation, the heat absorbed and re-radiated by the planet. This last-named radiation is predominantly of long wave lengths, 5 $\mu$

[134] *Sci. Pap. of the U. S. Bur. of Stand.*, **17**, 725, 1922.

[135] This general method of spectrophotometry by filters and much useful information on what materials to use for filters will be found discussed by D. C. Stockbarger in W. E. Forsythe's "The Measurement of Radiant Energy," McGraw Hill Book Company, Inc., New York, 1937, p. 98.

[136] *Journal Franklin Inst.*, **199**, 785, 1925; **200**, 103, 1925.

to 25 $\mu$ (where solar radiation is very weak), with a maximum lying in the region 8 $\mu$ to 15 $\mu$.

Planetary temperatures were determined from the observations in four ways. 1. By comparisons of the observations of planets with observations of terrestial sources of known temperatures, qualitative or semi-quantitative temperature estimates were made. 2. More reliable quantitative results were obtained by observing the intensity of the planetary radiation lying within wave-length ranges 8 $\mu$ to 12.5 $\mu$ and 12.5 $\mu$ to 15 $\mu$, forming the ratio of those intensities, and comparing the ratio found with a similar ratio observed for the moon. 3. Temperatures were determined by comparison of the ratio of the intensity of planetary radiation to the wave-length ranges 8 $\mu$ to 12.5 $\mu$ and 12.5 $\mu$ to 15 $\mu$ with a calibration curve determined by theory from the known laws of spectral radiation of a black body at various temperatures and the observed transmission coefficients of the earth's atmosphere. 4. Finally, temperatures were computed by applying the fourth power law of total radiation to the observations made with and without the water cell. This last method, originally suggested by Russell and worked out in detail by Menzel,[137] is the method now generally used in studies of planetary temperatures.

In addition to studies of the general temperatures of the planets, Coblentz and Lampland also made a number of very interesting determinations of temperatures for small selected areas of the planets Mars and Venus with their vacuum thermocouples.

In 1921 Pettit and Nicholson[138] using the 100-inch reflector at Mount Wilson began a series of experiments in the application of vacuum thermocouples to various astrophysical problems generally of the same type as those examined by Coblentz and Lampland. Their general apparatus was, in principle, very similar to that of Coblentz. They employed, as he did, a simple compensated thermocouple having both junctions completely exposed to sky illumination, and hence the effect of any background radiation was eliminated. Galvanometer deflections were recorded photographically on a moving photographic plate, the galvanometer and its auxiliary apparatus being well mounted at some distance from the thermocouple. In making observations, Pettit and Nicholson shifted the star image alternately from one junction of the thermocouple to the other (in the manner originally suggested by Pfund in 1913) and in this way obtained double deflections.

In addition to making numerous observations of various aspects of the sun, moon, and planets, as did Coblentz and Lampland, Pettit and Nicholson[139] made, during the years 1922 to 1927, a long and interesting series of measurements of radiometric magnitudes and water-cell

[137] *Ap. J.*, **58**, 65, 1923.
[138] *Ap. J.*, **56**, 295, 1922.
[139] *Ap. J.*, **68**, 279, 1928.

transmissions for 124 stars of all spectral classes including dwarfs, giants from spectral class F5 to class M0, spectroscopic binaries, eclipsing variables, long period variables, and cepheids.

In this work Pettit and Nicholson[140] defined the radiometric magnitude of a star as the visual magnitude of an A0 star which would give the observed galvanometer deflection, and the heat index of a star as the visual magnitude of a star *minus* the radiometric magnitude. Put in terms such as have been used previously, they established the zero point of the radiometric scale so that it was in agreement with that of the photographic and photovisual scales.[141] The heat index of an A0 star was thus, like the color index (according to the international definition at least!), equal to zero, and the scale of the radiometric magnitudes was, like the photovisual and photographic scales, a Pogson Normal Scale.

Most of the stars measured[142] at Mount Wilson were brighter than radiometric magnitude 4.2, for which the galvanometer deflection[143] exceeded two mm. In some instances, however, stars as faint as radiometric magnitude seven, for which the galvanometer deflection was between 0.1 and 0.2 mm were observed. Under good conditions these deflections were perfectly definite and could be determined to an accuracy corresponding to approximately 0.1 magnitude. For galvanometer deflections less than 40 mm (magnitude $= +1$) the uncertainty in the galvanometer reading was found to be nearly independent of the size of deflection.[144]

In theoretical astrophysics it is convenient to introduce a magnitude system different from any yet discussed, the so-called bolometric mag-

[140] *Pub. A. S. P.*, **34**, 181, 1922.

[141] If we read more into the definition than is actually stated by Pettit and Nicholson, we could also add "between visual magnitudes 5.5 and 6.5."

[142] Considerable care was taken to make these measurements, which extended over several years, homogeneous. Generally, the observing program for each night included two stars which were observed at three or more zenith distances covering the entire range in zenith distance for the rest of the stars on the list. This enabled the extinction coefficient to be determined each night and all the observations to be reduced to the zenith.

As the program progressed, however, it was noticed that the observed radiometric magnitudes of red stars decreased and those of blue stars increased with the time elapsed since the silvering of the Newtonian flat, the reflectivity of which thus obviously underwent great variations with time. A correction was therefore applied to all observations in order to allow for the effect of the tarnishing of the silver coat.

Corrections were also applied to reduce all observations to the equivalent of those made with rock salt windows in the thermocouple cell (not all cells were equipped with such windows).

[143] For stars of radiometric magnitude 0, the galvanometer deflection was 100 mm, magnitude +5, 1 mm, and magnitude +10, 0.01 mm.

[144] This effect is analogous to the seeing accuracy limit for photocell-amplifier combinations which will presently be discussed in detail. The effect of bad seeing on the uncertainty of a galvanometer deflection was a function of the size of the thermocouple receiver. Moonlight and sunlight apparently had little effect on the deflections because of the compensated thermocouple having two visible junctions.

nitude scale, which is more nearly like the radiometric scale than any other. The bolometric magnitude of a star is, according to Eddington,[145] "a measure of the heat-intensity of a star in the same way that the visual magnitude is a measure of its luminous intensity or the photographic magnitude is a measure of its photographic intensity." In the bolometric magnitude scale the intensity, I, which appears in the magnitude equation derived from Fechner's law is the total or integrated intensity of the star's radiant energy as seen outside the earth's atmosphere.

"Black-body radiation," Eddington states,[146] "has maximum luminous efficiency when it corresponds to a temperature of about 6500°, and the zero of the scale of bolometric magnitude is chosen so as to agree with the visual magnitude for stars of this effective temperature. At any other temperature a greater amount of radiant energy is required to produce the same intensity of light, so that the bolometric magnitude is brighter (numerically smaller) than the visual magnitude." Eddington, on the basis of Plank's law of black-body radiation and Nutting's measurements of the visual intensities of energy of different wave length, has tabulated[147] (as a function of stellar temperature) the corrections necessary to convert visual magnitudes into bolometric magnitudes. Hertzsprung,[148] in 1906, starting from Plank's law and the visibility measurements of Langley, Abney, and others, derived a formula for achieving this same transformation which is in excellent agreement with Eddington's tabulated results.

Pettit and Nicholson have made use of their radiometric magnitudes to derive bolometric magnitudes, the corrections necessary to accomplish this transformation being, in general, rather small. In establishing the zero point of their bolometric scale, Pettit and Nicholson did not following Eddington precisely, but in theory took as their standards giant stars of class G0. Observationally, in determining their zero point they made use of eight giant stars lying between spectral classes F5 and G5, and also the stars Procyon and $\epsilon$ Leonis. The scale thus established differs from Eddington's by $0^m.11$ in the sense m (Eddington) — m (Pettit and Nicholson) $= -0^m.11$.

The thermoelement and the radiomicrometer are electric in nature; the radiometer, on the other hand, is a thermal instrument. Its history dates back to the time of Fresnel who observed the repulsion of a small body subjected to irradiation by a beam of light. Later, about 1876, Sir William Crooks became interested in the device, and his studies led to the construction of the vane type of radiometer such as is commonly seen spinning in opticians' windows. A few years later still, at the

[145] "The Internal Constitution of the Stars," Cambridge Univ. Press, 1926, p. 13.

[146] *Op. Cit.*

[147] *Op. Cit.*, pp. 138, 139. Kuiper (*Ap. J.*, **88**, 429, 1938) has made an extended study of bolometric corrections.

[148] ***Zeitschrift fur wissenschaftliche Photographie*, 4**, 43, 1906.

end of the last century, E. F. Nichols[149] further improved the vane radiometer and developed the instrument to the point where it became a reliable device useful in the study of infrared radiation.

Nichols' radiometer consisted of a pair of vanes, the receivers, mounted on a light glass rod or staff at the bottom of which was a small plane mirror to indicate deflections in the manner of a galvanometer. This staff was suspended by a fine quartz fiber in a partially evacuated case (pressure 0.02 mm Hg). The vanes consisted of thin mica discs two mm in diameter; they were mounted on a short glass rod (distance between vanes, center to center, 4.5 mm) which was fastened at right angles to the glass staff. The pair of receivers was blackened on one side. Radiation to be measured was allowed to fall on the darkened side of one vane while the other served as a compensator for stray radiation.

The radiometer was designed so that the vanes were only a short distance in front of a window. Radiation to be measured fell upon one of the vanes which thus became warmed. Air currents were set up between the vane surface and the window and there resulted a deflection of the system (in the fashion of a galvanometer) until the recoil torque was balanced by the torque arising from the torsion of the quartz fiber. The deflection of the system as indicated by the mirror was a measure of the temperature of the surface of the receiver, and hence of the amount of radiant energy falling upon it.

The first astronomical application of the radiometer was made during 1898 at the Yerkes Observatory by Nichols[150] when he measured the radiation received from Arcturus, Vega, Jupiter, and Saturn, and demonstrated the usefulness and sensitivity of the device. Little use was made of the radiometer in the field of astronomy for some years thereafter, however, most interest in the field of astronomical radiometry tending rather generally to the use of thermoelements as receivers.

The difficulties experienced in 1923 by Abbot and Aldrich[151] in the measurement of the distribution of energy in stellar spectra with a vacuum bolometer have already been mentioned. Nichols, in view of certain new developments which he had made in the radiometer by that time, suggested that the measurements might be made more satisfactorily by means of an improved type of that device, and offered to supply such an instrument. In 1923, therefore, Abbot and Aldrich[152] repeated their measurements of the previous year using a new Nichols radiometer having vanes of dimensions $0.5 \times 1.5$ mm which had a distance of 2.5 mm between their centers. The spectrum surveyed with the radiometer had a length of 43 mm between wave lengths 0.437 $\mu$ and

[149] *Phys. Rev.*, **4**, 297, 1897.
[150] *Ap. J.*, **13**, 101, 1901.
[151] *Smithsonian Misc. Coll.*, **74**, No. 7, 1923.
[152] C. G. Abbot, *Ap. J.*, **60**, 87, 1924.

2.224 $\mu$, and was formed by a spectrometer equipped with a 60° glass prism and located at the coudé focus of the 100-inch reflector. Radiometer deflections were observed at various points in the spectra of the sun and of nine bright stars, ranging in brightness from magnitude —1.6 (Sirius, type A0) to a variable star of magnitude between 3.1 and 3.9 ($\alpha$ Herculis, type M3). Of the stars measured $\alpha$ Orionis gave the maximum spectral deflection, 50 mm.

Later, in 1928, Abbot[153] made further spectrophotometric measurements with a still more sensitive radiometer of his own construction. The vanes of this instrument were of dimensions 0.4 by 1.0 mm, the distance between their centers being 1.2 mm. Each vane was built of three parallel laminae of flies' wings, of which the front one was painted black and the two rear ones were unpainted. The laminae were separated by spaces of about 0.1 mm in order that the communication of heat from front to back would be impeded. The mirror, by means of which deflections were measured, was of dimensions 0.9 by 1.0 mm and was made of microscope cover glass which had been ground and polished to about half the usual thickness, and then platinized on both sides by sputtering. The whole system, including vanes, glass stem, and mirror, weighed 0.94 mg.

Some notion of the excessive fineness of the quartz fiber from which the system was suspended may be had from the fact that when used in full atmospheric pressure, forty-four complete turns of the top support could be made before the suspended system began to rotate in response. To the radiometer system, the air acted as though it were viscous (as tar would be to an ordinary mechanism), so small was the torque resulting from the torsion of the fiber.

The entire system was plaecd in an optically figured quartz cylinder which was exhausted to 0.0001 mm pressure and then filled with hydrogen to a pressure of 0.23 mm. This latter gas was used rather than air in order to avoid excessive damping of the radiometer.

With the aid of the large 60° prism at the coudé focus of the 100-inch reflector, the spectral energy curves of 18 stars and two planets were examined. The faintest of the stars observed was of magnitude 3.8; the wave-length range covered by the observations extended from 0.423 $\mu$ to 2.224 $\mu$, the measurements being made at nine points in the spectrum. The results obtained were as good as could be expected, but several improvements in the apparatus were, according to Abbot, still necessary: 1. Continuous recording should be introduced. 2. The wave-length range of the measurements should be extended in both directions. 3. More exact standardization of the observations in terms of radiation of known spectral energy distribution should be sought. 4.

[153] *Ap. J.*, **69**, 293, 1929. The instrument described in this paper is undoubtedly one of the most unusual instruments to be found anywhere in the history of photometry.

Greater sensitivity without increased accidental disturbances was very desirable. "With such improvements," stated Abbot,[154] "a long campaign of observations of stellar spectral distribution would be justified."

In 1934 an attempt[155] was made in cooperation with Stebbins to observe the spectral energy curves of stars in ten wave-length regions selected by Christiansen filters, but owing to the wave-length dependence of the sensitivity of the photoelectric cell used in the measuring device, the observations were unsuccessful. In 1938 Abbot and Hoover observed a few stars with the same set of Christiansen filters, but substituted a Clark thermopile for the photocell. Good results were obtained for the brighter stars, but electromagnetic and temperature effects caused drift and short period variations in the galvanometer readings. It was not possible, therefore, to use the galvanometer at its full sensitivity, and hence faint stars could not be observed.

In 1945 another attempt to obtain stellar energy spectra was made by Abbot, who this time used as a dispersing agent a grating having 300 lines per mm, and a radiometer as the measuring instrument. Wandering of the zero point of the radiometer, however, (probably caused by Brownian motions according to Abbot) proved to be a large source of error which vitiated the results obtained.

At present, plans are being made for a new attack[156] on the problem of observing stellar energy spectra. The dispersing agent for this new set of observations will be a specially designed cemented prism giving more nearly linear dispersion than a single glass prism. The energy receiver will be a new and sensitive radiometer. This new radiometer has vanes made of pieces of aluminum foil of dimensions $0.2 \times 0.44$ mm. The separation of the vanes, center to center, is slightly greater than two mm. A small fragment of a housefly's wing is fastened behind the vanes to act as a heat shield to reduce heating of the back of the suspension, and the entire radiometer is shielded in a special case in order to prevent electrostatic disturbances and changes or inequalities of temperature, and to reduce any possible effects of jarring or vibration.

It is calculated that with this apparatus at the coudé focus of the 100-inch reflector, the energy spectra of a dozen or more stars can be observed with maximum radiometer deflections of from three to ten cm. The short-period variations in the radiometer deflections, according to Abbot, should not exceed 0.5 mm, and the drift should be zero.[157]

*(To be continued)*

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[154] *Ap. J.*, **69**, 311, 1929.

[155] *Ann. Astroph. Obs. Smithsonian Inst.*, **6**, 17, 1942.

[156] Abbot, *Smithsonian Misc. Coll.*, **104**, No. 22, 1946.

[157] In addition to making observations of stellar energy spectra with the various pieces of apparatus described, Abbot has made several attempts to devise new and more sensitive equipment for measuring radiant energy. The devices tried have included the kampometer (Abbot, *Smithsonian Misc. Coll.*, **89**, No. 3, 1933), and improved galvanometers for use in conjunction with thermoelements (Abbot, *Ann. Astrophys. Obs. Smithsonian Inst.*, **6**, 17, 1942).

# Geological Structures Possibly Related to Lunar Craters

By ROBERT S. DIETZ

The recent achievement of detecting a radar echo reflected from the surface of the moon has once again focused popular attention on the earth's satellite. Although a popular weekly magazine has stated that the "other side" of the moon is the greatest lunar mystery, this mystery is probably a poor second as compared to the enigma of the origin of the surface features on "this side" of the moon.

Astronomers, geologists, and other scientists, who have pondered the origin of the lunar craters and related features on the moon's face, have examined the earth's surface in search of features that may be genetically related to those of our satellite. Those who favor the meteoroidal impact theory of origin of the lunar craters point out the close resemblance between Meteor Crater, Arizona, and most of the small lunar crater pits. However, this terrestrial impact crater lacks a central hill such as is characteristic of many of the medium-sized lunar craters. Those who favor the volcanic theory of origin of the lunar craters point out aspects of resemblance between certain terrestrial volcanic craters and those of the moon. Terrestrial volcanic craters formed by explosion with little effusion of volcanic material most closely resemble lunar craters; yet, few of these have the high circularity and radial symmetry characteristic of the lunar features. Although previously overlooked, there is a third group of terrestrial structures which are similar in many respects to lunar craters and which may have been formed by similar processes. These features are the roughly circular areas of intensely disturbed and shattered rock in ancient geological formations which appear to be the result of a violent natural explosion. The source of the explosive force is problematical.

These explosion structures are, in general, characterized by: (1) a roughly circular outline and a radial symmetry which, in some cases, is slightly bilateral; (2) a variation in size of from less than a mile to at least eight miles in diameter and possibly up to as much as 75 miles in diameter; (3) an intensely shattered and jumbled central uplift surrounded by a ring-shaped depression and sometimes by other ring-shaped uplifts and depressions of diminishing amplitude forming a "damped-wave" structure; (4) the central part of these structures contains sheared, shattered, and powdered rock and, in some cases, "shatter-cones" which are indicative of explosive shock; (5) volcanic, plutonic, or hydrothermally altered rock is not found. Identified examples of these structures in the United States include the Flynn Creek disturbance in Tennessee,[1] the Wells Creek Basin structure in Tennessee,[2] the Howell disturbance in Tennessee[3], the Kentland structure

in Indiana,[4] the Jeptha Knob structure in Kentucky,[5] the Serpent Mound structure in Ohio,[2], and the Sierra Madera structure in Texas.[6,7] These structures are sufficiently alike to suggest that they were all formed in a similar manner and they differ sufficiently from other known geological structures to indicate that they form a specific structural type. Until the mode of origin of these features is definitely established, the present writer suggests that they be termed "crypto-explosion" structures.

A resemblance between these crypto-explosion structures and lunar craters is most clearly apparent in the Paleozoic-aged Flynn Creek structure which, although filled and covered with later marine sediments, uplifted, and sub-aerially eroded in the few hundreds of millions of years that have elapsed since its formation, contains a nearly two-mile-wide explosion crater with a central uplift. Here, then, is an example of a terrestrial explosion crater with a central hill as well as other shape aspects such as a circular outline, radial symmetry, a rim of rock detritus, and a crater depressed below the surrounding terrain all of which are characteristic of lunar craters. As reconstructed by Wilson and Born,[1] the Flynn Creek crater probably bears a closer resemblance to a typical lunar crater than any present-day terrestrial feature.

A widely accepted belief is that these crypto-explosion structures are crypto-volcanic,[3] *i.e.,* produced by a deep-seated explosion of gases derived from a magmatic intrusion and without the extrusion of any volcanic material. According to this theory, if the explosion is strong and concentrated, an explosion crater is formed, and, if the explosion is weak and unconcentrated or "muffled," a jumbled domal uplift is formed. An explosion crater with a central uplift such as at Flynn Creek or at Steinheim Basin, Germany,[2] requires a strong explosion blowing out the crater followed at a later time by a "muffled" explosion producing the central uplift. Weaknesses of the crypto-volcanic theory are that: (1) the occurrence of a deep-seated explosion of this type is questionable; (2) if such an explosion can occur, it is likely that it would be accompanied by some igneous material and especially by alteration of the rock due to escaping gases; (3) these features are largely present in non-volcanic regions in the earth's crust.

An alternate explanation is that these crypto-explosion structures are the scars formed by the high-velocity and explosive impact of large meteorites[7] such as has been postulated to explain lunar craters. Most crypto-explosion structures lack an explosion crater so that, according to the impact theory, they must be interpreted as the exposed "root" structure remaining after erosion of the crater or as formed subaqueously on the floor of the shallow seas that covered parts of the continents many time in the geological past by the impact explosion on the surface of the sea. In other words, some crypto-explosion structures

lacking an explosion crater may resemble the structure that might remain if Meteor Crater, Arizona, were hypothetically eroded and planed off to a depth of 1000 feet, whereas others may be jumbled sea-floor rock structures formed below a crater which had only ephemeral existence in the sea water. Boon and Albritton[8] have shown theoretically that the "damped-wave" form with an intensely jumbled center probably results from an explosive "backfire" following the elastic compression of water or rock by a missile traveling at many times the velocity of shock waves in terrestrial materials. The crater is formed by the blowing out of the central and the surface part of this rock structure in some manner which usually partially preserves the central uplift.

The greatest weakness of such an impact theory is that neither meteoritic fragments nor fused rocks have been found associated with these structures. However, it is unlikely that more than a few meteoritic fragments of the original mass would survive the impact. These fragments would be rapidly weathered and removed by erosion. Although it has been suggested that a large primary meteoroidal mass is buried beneath Meteor Crater, Arizona, the evidence is not convincing. It is more likely that meteoroidal impact structures contain no such primary mass.

Added strength is given to the impact theory by the Sierra Madera crypto-explosion structure which has been drilled to a depth of over two miles without revealing the presence of an igneous core. In fact, the structure appears to die out with increasing depth. Also, the present writer has noted that at the Kentland structure "shatter-cones" are oriented with their apices toward the top of the beds suggesting that the compressive deforming force came from above.

Thus, although the origin of these features is still open to question, further study of these terrestrial structures close at hand may help solve the origin of the lunar craters.

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# Cerebrospinal Meningitis and Sunspots

By WALTER G. BOWERMAN

Almost any statistical compilations for even such an advanced country as the United States are crippled by the short period of time during which data are available. So often anything prior to 1900 comes to us as though from the Dark Ages of ignorance, crudity, and superstition. Fortunately in New York City we have records of death by cause for 1866 and subsequently. Although the population has been increasing during the eighty years under review, the increase has been gradual, and the epidemics of cerebrospinal meningitis stand out rather clearly. In Table I these deaths are recorded in parallel columns with the sunspot numbers. The latter are tabulated every year in the journal of *Terrestrial Magnetism and Electricity* and also in the *U. S. Monthly Weather Review.*

TABLE I

| Year | Number of Deaths in N. Y. City from Cerebrospinal Meningitis | Daily Mean Number of Sunspots (Wolf & Wolfer) | Year | Number of Deaths in N. Y. City from Cerebrospinal Meningitis | Daily Mean Number of Sunspots (Wolf & Wolfer) |
|---|---|---|---|---|---|
| 1866 | 20 | 16.3 | 1899 | 394 | 12.1 |
| 1867 | 40 | 7.3 | 1900 | 306 | 9.5 |
| 1868 | 47 | 37.3 | 1901 | 267 | 2.7 |
| 1869 | 51 | 73.9 | 1902 | 265 | 5.0 |
| 1870 | 32 | 139.1** | 1903 | 271 | 24.4 |
| 1871 | 48 | 111.2 | 1904 | 1403 | 42.0 |
| 1872 | 782* | 101.7 | 1905 | 2025* | 63.5** |
| 1873 | 290 | 66.3 | 1906 | 812 | 53.8 |
| 1874 | 158 | 44.7 | 1907 | 642 | 62.0 |
| 1875 | 146 | 17.1 | 1908 | 351 | 48.5 |
| 1876 | 127 | 11.3 | 1909 | 326 | 43.9 |
| 1877 | 116 | 12.3 | 1910 | 294 | 18.6 |
| 1878 | 97 | 3.4 | 1911 | 225 | 5.7 |
| 1879 | 108 | 6.0 | 1912 | 196 | 3.6 |
| 1880 | 170 | 32.3 | 1913 | 202 | 1.4 |
| 1881 | 461* | 54.3 | 1914 | 207 | 9.6 |
| 1882 | 238 | 59.7 | 1915 | 119 | 47.4 |
| 1883 | 223 | 63.7** | 1916 | 176 | 57.1 |
| 1884 | 210 | 63.5 | 1917 | 187 | 103.9** |
| 1885 | 202 | 52.2 | 1918 | 262* | 80.6 |
| 1886 | 223 | 25.4 | 1919 | 171 | 63.6 |
| 1887 | 203 | 13.1 | 1920 | 123 | 38.7 |
| 1888 | 173 | 6.8 | 1921 | 147 | 24.7 |
| 1889 | 145 | 6.3 | 1922 | 110 | 14.7 |
| 1890 | 136 | 7.1 | 1923 | 77 | 5.8 |
| 1891 | 189 | 35.6 | 1924 | 104 | 16.7 |
| 1892 | 230 | 73.0 | 1925 | 93 | 44.3 |
| 1893 | 469* | 84.9** | 1926 | 114 | 63.9 |
| 1894 | 213 | 78.0 | 1927 | 120 | 69.0 |
| 1895 | 204 | 64.0 | 1928 | 540* | 77.8** |
| 1896 | 178 | 41.8 | 1929 | 486 | 65.0 |
| 1897 | 232 | 26.2 | 1930 | 267 | 35.7 |
| 1898 | 357 | 26.7 | 1931 | 207 | 21.2 |

| Year | Number of Deaths in N. Y. City from Cerebrospinal Meningitis | Daily Mean Number of Sunspots (Wolf & Wolfer) | Year | Number of Deaths in N. Y. City from Cerebrospinal Meningitis | Daily Mean Number of Sunspots (Wolf & Wolfer) |
|---|---|---|---|---|---|
| 1932 | 114 | 11.1 | 1939 | 36 | 88.7 |
| 1933 | 73 | 5.7 | 1940 | 17 | 67.8 |
| 1934 | 73 | 8.7 | 1941 | 42 | 47.5 |
| 1935 | 243* | 36.1 | 1942 | 84 | 30.6 |
| 1936 | 226 | 77.1 | 1943 | 246 | 16.3 |
| 1937 | 101 | 114.4** | 1944 | 199 | 9.6 |
| 1938 | 53 | 109.5 | 1945 | 102 | 33.0*** |

*—Year of Epidemic Peak.
**—Year of Sunspot Maximum.
***—Estimated provisionally.

It will be observed from Table I that the 782 deaths in 1872 were a distinct peak as contrasted with the numbers in nearby years. This peak occurred two years after the year of maximum in sunspot numbers; (139 in 1870). In 1878 there was a trough with 97 deaths and also a low point with three sunspots. Then in 1881 an epidemic led to 461 deaths just two years prior to the sunspot maximum of 64 in 1883. The low point in sunspots was in 1889 and in deaths in 1890. When we come to 1893 there was a peak in both sets of figures, 469 deaths, and 85 sunspots as the daily average. The next low point in sunspots was in 1901 and in deaths in 1902. Then in 1905 we find 2,025 deaths as by far the largest peak in the series, balanced by a maximum in sunspot numbers in the same year. A similar regularity is to be found in the rest of the columns, subject of course to the minor variations which always characterize vital phenomena.

In Table II the years of maxima are set forth side by side and also the differences in years between the respective dates. Of the seven periods three agreed exactly and the others differed by one or two years.

TABLE II

| Year of Peak in Deaths from Cerebrospinal Meningitis | Year of Sunspot Maximum | Difference in Years of Maxima + | Difference in Years of Maxima — |
|---|---|---|---|
| 1872 | 1870 | 2 | |
| 1881 | 1883 | | 2 |
| 1893 | 1893 | .. | .. |
| 1905 | 1905 | .. | .. |
| 1918 | 1917 | 1 | |
| 1928 | 1928 | .. | .. |
| 1935 | 1937 | | 2 |

The data may be summarized in another way also: The average number of deaths in years of sunspot maxima was 304 and at minima 138, a ratio of 2.2. If we take the five years centering about maxima

and the corresponding five years centering about minima the average number of yearly deaths is 347 against 158; again a ratio of 2.2. If we take three years centering at maxima and three at minima, we obtain 349 and 137, a ratio of 2.6. Thus it seems that, almost however the data are combined, there was a distinct tendency for deaths from cerebrospinal meningitis to fall more heavily and frequently at or near a maximum in sunspot numbers.

Similar data for Massachusetts from 1872 and for the entire United States from 1900 have been published. In all but one of the seven maxima of sunspot numbers there was a peak in Massachusetts deaths from cerebrospinal meningitis in the same year or in an adjacent year. The same applies for the four peaks of the United States material. These years appear in Table III.

TABLE III

| *Massachusetts* Years of Peak in Death Rate from Cerebrospinal Meningitis | | Years of Sunspot Maxima | | *United States* Years of Peak in Death Rate from Cerebrospinal Meningitis |
|---|---|---|---|---|
| 1870-72 | * | 1870 | | N.G.** |
| 1884 | * | 1883-1884 | | N.G. |
| 1889 & 1897 | | 1893 | | N.G. |
| 1905 | * | 1905 | * | 1905 |
| 1917 | * | 1917 | * | 1918 |
| 1929 | * | 1928 | * | 1929 |
| 1937 | * | 1937 | * | 1936 |

*—Agreement within a year.
**—Not given.

The years shown in Table III have been written down from material given by Mary Gover and Glee Jackson in *U. S. Public Health Reports*, March 29, 1946 (vol. 61; no. 13, pp. 433-450), which article includes a valuable bibliography. They showed curves for meningitis cases in a number of countries from every continent, usually for the period 1920-1943. Those curves differed markedly from one another, which might seem to indicate that sunspots could have nothing to do with the matter. However, the student of sunspot literature will recall that the terrestrial effects of sunspots are much more marked in the United States than in certain other parts of the world such as England, for example. Our knowledge on this is still rather fragmentary. Yet it is possible that the vast land mass to the north of the United States in which ozone accumulates periodically may be a causative factor in this connection. Some suggestions along this line were given by Dr. Ellsworth Huntington in the book "Mainsprings of Civilization" (May, 1945), of which a second edition is now about to appear. This particular point as to the reason for the geographic differential influence of sunspots on terrestrial affairs is hypothetical. I put it forth, however, as a tentative explanation of how we could have such remarkable results as shown above for this particular epidemic disease in the United

States, although not equally so in every other part of the earth. The reader who wishes to study further regarding sunspots can do no better than to read the book "Sunspots and Their Effects" by Dr. Harlan T. Stetson (1937).

The data for other countries given in graphs only by Gover and Jackson cover less than 25 years (about two sunspot cycles) and deal with cases only, instead of deaths or death rates. The ratio of deaths to reported cases for this disease in the United States has decreased rather steadily from 90% in 1926 to 17% in 1944. Thus we are in a position of still seeking for more complete facts. The use of sulphonamide drugs seems likely to almost obliterate cerebrospinal meningitis from countries where those remedies are readily available. But since airplane travel is becoming ever more widespread and frequent, we may feel the truth in the parody, "The price of good health is eternal vigilance." The public health officials may be well advised to double their vigilance in those years when sunspot numbers are at or near their maximum. It now appears that 1948 may be the next year of maximum in sunspot numbers.

To most physicians and astronomers as well as other people the relationships brought out in the above pages will seem strange and exotic. However, some suggestions were given in the May, 1935, *Quarterly Bulletin of the N. Y. City Health Department* of which Dr. Charles Bolduan was then editor. He gave the deaths and death rates for cerebrospinal meningitis covering the 58-year period, 1877-1934, as well as an attractive chart of the death rates. He stated, "It is evident that periods of increased prevalence recur with considerable regularity at intervals of approximately eleven or twelve years. The number of reported cases is available since 1900, but for many years the reporting was very incomplete, for at times the deaths exceeded the cases. . . In 1904 and 1905, the case fatality rate was over 65%; in 1928 it was 49%. The decrease can probably be credited to the use of specific antimeningococcus serum in treatment."

The reader who has seen my paper "Acute Anterior Poliomyelitis" (*Archives of Pediatrics,* February, 1945) will recall that for that disease it was the case-fatality rate which seemed most closely in harmony with the sequence of sunspot numbers. In view of the remarks quoted above from Dr. Bolduan no use was here made of case-fatality rates for meningitis.

Even though there has been a noteworthy parallelism for a number of years between death rates and cerebrospinal meningitis at New York City and the sunspot cycle, it should not be inferred that this will always be the case. As Ellsworth Huntington has pointed out: "Many terrestrial phenomena have a most exasperating way of fluctuating in harmony with sunspots for a considerable period and then suddenly showing a complete reversal of the old relationship. The number of

storm tracks in south-central Canada fluctuated almost perfectly in harmony with the sunspot numbers for 36 years (1887-1923). Before and after the 36 years, however, the storms and the spots show an almost perfect opposition. (In eastern Canada an even closer agreement lasted from 1884 to 1930.) This kind of agreement, followed by a reversed agreement, occurs so often that the two together offer one of the most tantalizing problems in the field of solar and terrestrial relationships." The peak of 246 deaths in 1943—see Table I—one year prior to a sunspot *minimum* is apparently a reversal of this kind.

## The Planets in December, 1946

By LELAND E. CUNNINGHAM

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

*Sun.* Throughout the month the sun will be near the southernmost point of its annual path; it will reach this point on December 22, at 5 A.M., C.S.T., at which time winter will begin.

*Moon.* The phases of the moon will occur as follows:

| | | | C.S.T. |
|---|---|---|---|
| First Quarter | December | 1 | 4 P.M. |
| Full Moon | | 8 | 12 Noon |
| Last Quarter | | 15 | 5 A.M. |
| New Moon | | 23 | 7 A.M. |
| First Quarter | | 31 | 6 A.M. |

There will be a total eclipse of the moon on the forenoon of December 8, Central Standard Time, but the moon will already have set for observers on the North American continent, except the extreme northwestern portion.

*Evening and Morning Stars.* Venus and Jupiter will be brilliant morning stars close to the horizon at the beginning of the month, but very conspicuous toward the end; Mercury will be visible with difficulty for a few days near the 9th. Saturn will be approaching opposition. There will be no visible evening star.

*Mercury.* Mercury will reach a stationary point in right ascension on the last day of November, but it will continue to move away from the sun until December 9, when it will be in greatest elongation west. It may be seen low in the southeast just before sunrise for a few days near this date. After that it will gradually move closer to the sun.

*Venus.* Venus will be a splendid morning object throughout the month; it will reach its greatest brilliancy, magnitude —4.4, on December 23. At the beginning of the month it will be slowly retrograding, but it will become stationary on the 6th, and thereafter will move eastward with increasing rapidity, but its motion will be less than the sun's, and so it will continue slowly to separate from the sun. During its retrograde motion Venus will almost return to Jupiter, which it passed on September 3; on December 10 they will be only a little more than a degree apart.

*Mars.* Mars will remain east of the sun, but by the end of the month will almost have lost its long race with it.

*Jupiter.* Jupiter will be a morning star near Venus, and much fainter than it. The pair will make a brilliant spectacle about December 10, when they will be less than two degrees apart.

*Saturn.* Saturn will be slowly retrograding in Cancer near δ Cancri and the Beehive. The rings have been slowly closing since 1943, and will continue until 1951, when they will be seen edgewise. They are still sufficiently open for satisfactory telescopic examination.

*Uranus.* Uranus will continue to retrograde in the eastern part of Taurus; it will be in opposition on the 12th. An occultation by the moon on the evening of the 8th will be visible throughout the eastern part of North America; however, it will occur so close to full moon that it will be very difficult to observe.

*Neptune.* Neptune will be in Virgo, and almost in quadrature at the end of the month.

Students' Observatory, Berkeley, California, October 13, 1946.

## Occultation Predictions for December, 1946

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

| Date 1946 | | Star | Mag. | Immersion Greenwich C.T. | Immersion *a* | Immersion *b* | Immersion Angle E from N | Emersion Greenwich C.T. | Emersion *a* | Emersion *b* | Emersion Angle E from N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | h m | m | m | ° | h m | m | m | ° |
| | | Occultations Visible in Longitude +72° 30′, Latitude +42° 30′ | | | | | | | | | |
| Dec. | 5 | ξ¹ Ceti | 4.5 | 20 3.5 | 0.0 | +1.4 | 79 | 20 55.9 | −0.1 | +1.9 | 227 |
| | 6 | ξ Arie | 5.5 | 2 47.2 | −1.9 | +0.2 | 78 | 3 57.1 | −1.1 | +1.2 | 218 |
| | 8 | Uranus | 5.9 | 22 28.2 | +0.4 | +1.5 | 55 | 23 15.9 | −0.1 | +1.1 | 273 |
| | 10 | ε Gemi | 3.2 | 5 44.1 | −1.8 | −0.4 | 106 | 6 57.6 | −1.8 | +0.4 | 253 |
| | 11 | 176 B.Gemi | 6.3 | 0 17.5 | +0.3 | +1.0 | 91 | 1 9.1 | 0.0 | +1.3 | 265 |
| | 11 | κ Gemi | 3.7 | 2 36.7 | −0.5 | +1.2 | 92 | 3 39.9 | −0.9 | +1.3 | 266 |
| | 11 | 5 B.Canc | 6.4 | 11 9.8 | +0.3 | −3.3 | 159 | 11 46.9 | −1.3 | 0.0 | 233 |
| | 15 | ν Virg | 4.2 | 11 8.0 | −1.4 | −1.5 | 133 | 12 26.8 | −1.5 | −1.5 | 299 |
| | 19 | μ Libr | 5.8 | 10 30.0 | −0.9 | +0.4 | 116 | 11 45.0 | −1.1 | −0.3 | 310 |
| | 31 | 26 Ceti | 6.2 | 21 14.3 | −1.1 | +1.9 | 42 | 22 29.5 | −1.7 | +1.1 | 246 |
| | | Occultations Visible in Longitude +91° 0′, Latitude +40° 0′ | | | | | | | | | |
| Dec. | 2 | 257 B.Aqar | 6.3 | 0 2.5 | −2.5 | +0.1 | 91 | 1 10.9 | −0.7 | +1.6 | 201 |
| | 6 | ξ Arie | 5.5 | 2 14.4 | −1.3 | +1.5 | 55 | 3 29.3 | −1.5 | +1.2 | 236 |
| | 8 | Uranus | 5.9 | .. .. | .. | .. | .. | 23 14.0 | +0.2 | +0.7 | 288 |
| | 10 | ε Gemi | 3.2 | 5 11.2 | −1.6 | +0.4 | 102 | 6 21.7 | −1.6 | +1.4 | 247 |
| | 11 | κ Gemi | 3.7 | 2 30.0 | +0.1 | +0.4 | 77 | 3 24.8 | −0.4 | +1.0 | 278 |
| | 14 | BD+12°2284 | 6.4 | 12 56.8 | −2.1 | −0.7 | 90 | 13 59.2 | −0.4 | −2.6 | 338 |
| | 15 | ν Virg | 4.2 | 10 54.6 | −0.4 | −3.2 | 174 | 11 48.8 | −3.0 | +1.0 | 257 |
| | 18 | 623 B.Virg | 6.5 | 10 30.2 | −1.0 | +1.1 | 97 | 11 34.7 | −0.6 | −1.1 | 331 |

| Date 1946 | | Star | Mag. | IMMERSION Greenwich C.T. | a | b | Angle E from N | EMERSION Greenwich C.T. | a | b | Angle E from N |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | h m | m | m | ° | h m | m | m | ° |
| **Occultations Visible in Longitude +120° 0′, Latitude +36° 0′** | | | | | | | | | | | |
| Dec. | 1 | 257 B.Aqar | 6.3 | 23 2.2 | −1.4 | +1.7 | 67 | 0 23.1 | −1.8 | +1.6 | 238 |
| | 6 | ξ Arie | 5.5 | 1 45.8 | 0.0 | +2.6 | 16 | 2 34.9 | −1.8 | +0.8 | 279 |
| | 6 | 31 Arie | 5.7 | 9 24.5 | −0.8 | +4.4 | 3 | 9 51.1 | .. | .. | 313 |
| | 10 | ε Gemi | 3.2 | 4 39.3 | −0.3 | +1.3 | 77 | 5 40.3 | −0.8 | +1.2 | 264 |
| | 13 | η Leon | 3.6 | 12 33.8 | −2.2 | −0.6 | 103 | 13 51.4 | −1.2 | −2.2 | 318 |
| | 14 | BD+12°2284 | 6.4 | 12 10.9 | −1.3 | −2.1 | 150 | 13 25.6 | −2.4 | −0.3 | 277 |
| | 17 | 65 Virg | 5.9 | 13 26.3 | −0.2 | −2.7 | 171 | 14 24.3 | −3.0 | +1.0 | 263 |
| | 17 | 66 Virg | 5.8 | 14 28.8 | −0.3 | −2.7 | 174 | 15 30.8 | −3.1 | +0.3 | 265 |
| | 18 | 95 Virg | 5.5 | 11 31.9 | −0.8 | +2.1 | 77 | 12 19.2 | 0.0 | −1.9 | 347 |
| | 29 | 69 Aqar | 5.8 | 1 0.9 | −2.6 | −0.3 | 89 | 2 9.7 | −0.5 | +1.6 | 201 |
| | 29 | τ Aqar | 4.2 | 2 37.5 | −1.3 | +0.1 | 61 | 3 51.2 | −0.6 | +0.2 | 231 |
| **Occultations Visible in Longitude +98° 0′, Latitude +30° 0′*** | | | | | | | | | | | |
| Dec. | 1 | 257 B.Aqar | 6.3 | 23 40.7 | −3.2 | 0.0 | 100 | 0 44.0 | −0.6 | +2.8 | 189 |
| | 6 | ξ Arie | 5.5 | 1 48.9 | −1.5 | +1.5 | 65 | 3 2.9 | −1.4 | +1.9 | 222 |
| | 6 | 31 Arie | 5.7 | 9 28.2 | −0.6 | +1.2 | 31 | 10 11.7 | +0.2 | −1.7 | 291 |
| | 9 | 132 Taur | 5.0 | 11 35.1 | −0.7 | −0.7 | 85 | 12 33.3 | −0.1 | −1.1 | 280 |
| | 10 | ε Gemi | 3.2 | 5 0.5 | −2.2 | −1.2 | 131 | 5 48.1 | −0.8 | +3.6 | 212 |
| | 10 | 37 Gemi | 5.8 | 10 52.4 | −1.7 | −0.4 | 80 | 11 57.3 | −0.6 | −1.7 | 299 |
| | 11 | κ Gemi | 3.7 | 2 20.6 | +0.2 | +0.7 | 95 | 2 12.9 | 0.0 | +1.1 | 259 |
| | 13 | η Leon | 3.6 | 13 28.5 | −2.4 | −0.2 | 77 | 14 19.8 | +0.1 | −3.1 | 346 |
| | 14 | BD+12°2284 | 6.4 | 12 55.9 | −1.6 | −1.8 | 129 | 14 15.6 | −1.3 | −1.8 | 304 |
| | 17 | 65 Virg | 5.9 | 13 57.3 | −1.5 | −1.9 | 143 | 15 24.2 | −2.1 | −1.5 | 297 |
| | 18 | 623 B.Virg | 6.5 | 10 23.8 | −0.3 | −0.7 | 139 | 11 32.2 | −1.3 | +0.2 | 289 |
| | 18 | 95 Virg | 5.5 | 11 54.2 | −3.1 | +3.4 | 64 | 12 31.0 | +1.0 | −4.4 | 8 |
| | 29 | τ Aqar | 4.2 | 3 21.3 | .. | .. | 133 | 3 38.3 | .. | .. | 164 |

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

# Asteroid Notes

By HUGH S. RICE

Asteroid work has, on the whole, been at a low ebb for the last few years because the asteroid headquarters was in Germany. Important work has been going on elsewhere, however, at the Yale University Observatory and a few other places. But no one institution appears willing to undertake all the vast computations formerly done at the German headquarters.

This headquarters (at Dahlem, near Berlin) was called the Astronomisches Rechen-Institut until 1939, when the name was changed to the Coppernicus-Institut. This was the clearing-house for all asteroid work. Observations of the minor planets from countries all over the globe were sent in to the Institut. A great amount of mathematical work was necessary, in improving orbits, identifying lost asteroids, computing ephemerides of new planets, as well as computing opposition ephemerides for over 1500 known planets. The annual publication, *Kleine Planeten*, contained the summary of the work, with names, elements, ephemerides, and other data of all the asteroids.

As described in the June Popular Astronomy by Dr. Kuiper, the above work is far behind. The former editor, Gustav Stracke, has passed on, and the institute is split up, but much of the work has been gradually carried on. A part

of the original institute appears to be at Heidelberg, where Professors Kopff, Reinmuth, Gondolatsch, Rabe, and other leading figures, are located.

At the meeting of the International Astronomical Union, held in March, 1946, at the Danish Academy of Sciences and Letters, a number of commissions were set up to discuss important matters. Among these the asteroid situation was brought up, and it was decided that the regular ephemeris computations of known planets should be shared by the "Rechen-Institut" at Heidelberg and the Institute of Theoretical Astronomy at Leningrad. New planets were to have their orbits investigated and ephemerides calculated by the Berkeley Observatory in California. These three centers were to issue circulars of observations, as was done formerly by the Coppernicus-Institut. It is to be hoped that in time this work will have progressed enough so that observers will have more of the planets available. There are innumerable asteroids in the sky at all times but without ephemerides observations are at a standstill. By diligent work, observers could pick up right now many minor planets but would be unable to identify them. Such objects would ordinarily be known planets and not new ones however, the new or undiscovered ones being exceedingly faint.

The subjoined data on VESTA is a continuation of the ephemerides in our last issue. We have no others available.

EPHEMERIS OF VESTA, FOR $0^h$ U.T.
Equinox of Date

| 1946 | $\alpha$ h m | $\delta$ ° ′ |
|---|---|---|
| Nov. 20 | 23 48.8 | —11 29 |
| 28 | 23 51.5 | —10 41 |
| Dec. 6 | 23 55.6 | — 9 44 |
| 14 | 0 0.9 | — 8 41 |
| 22 | 0 7.4 | — 7 32 |

Hayden Planetarium, American Museum of Natural History, New York, N. Y., October 19, 1946.

# METEORS AND METEORITES

## Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The night of October 9/10 furnished at least to the United States the finest meteor shower seen for two generations. The Draconid meteors, which follow the orbit of Giacobini-Zinner's Comet, gave a grand display, and, as the shower had had wide advance publicity, large numbers of people had made preparations to observe. To the date of this writing (October 22) about 250 reports, from at least two to three times that number of individuals, have come to Flower Observatory. The number is so large that, arriving as they are coincident with the beginning of the session and the organizing of larger classes than usual, it has been impossible so far even to acknowledge most of them, and analysis must await arrival of others still enroute and the finding of time to undertake it. But I feel safe in saying that never before has such a mass of good data, made according to plan, been available for the study of a meteor shower. We can hope therefore that its complete working up will give us a more detailed picture than ever before

presented of a cross section of a great meteor stream, certainly that is since the time of the great showers from 1866 to 1872 inclusive.

In general, basing the statement on reports at hand, New England, S. E. New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North and South Carolina, W. Virginia, and most of Georgia seem to have been cloudy. At least part of every other state seems to have had clear or partly clear weather. The writer had made considerable preparations to observe from Ursinus College, Pa., which is in the open country and some 30 miles N. W. of here. Simultaneous work was planned with other A.M.S. observers in the outskirts of Philadelphia and a group at Princeton, N. J. The first week of October was unusually clear; we have had many good nights since, but the period October 8-10 was hopeless, particularly October 9. So, after 48 years of work on meteors, the writer lost the one splendid shower of his lifetime! However, if those of us in this area were out of luck, many of the A.M.S. observers elsewhere were ready and did their full part. Also scores of intelligent persons, not members, both men and women, wrote me promptly. The average weight of the reports, and their clearness, are of a high order. In several cities, a whole science class of a high school observed, each member sending in his separate report. It can readily be seen that the writer is, as yet, literally swamped, and the mere arranging of the reports, much less their analysis, is a large task. The best that can be done will be to publish in successive "Meteor Notes" selected data, and give out the results as they are derived. To print, in detail, all the reports already received literally would completely fill every issue of POPULAR ASTRONOMY for a year! It is obvious that such a procedure is impossible, hence most reports will have to be condensed to their bare essentials. Meantime, however, it seems to me that a typical one, from about the middle of the country, should be given in full detail. This does not imply that many others are not equally excellent—they are!—but our readers should at once have a chance to see what a trained group could accomplish. Also its leader, Professor B. S. Whitney of the University of Oklahoma, not only has been an A.M.S. member for two decades but has been on my staff at Flower Observatory for two years during which he did outstanding work. Even here, however, the report covers only rates, as the maps and photographs have not yet arrived from him. A study of the data will show pretty clearly how splendid the shower really was, especially when we remember that the Moon was full. Under such conditions we always divide the observed hourly rate by 0.4, even for *perfect* conditions of transparency, to get the corrected rate. The least haze or cloud may well drop the factor F to 0.3 or even 0.2. Hence we may conclude with much certainty that, without the bright moonlight, about three times as many meteors should have been visible to the average observer.

DRACONIDS, OCTOBER 9, 1946

Counts at University of Oklahoma Observatory

Observers faced radiant unless otherwise noted

| Time (P.M., C.S.T.) | Observer | No. Meteors | Rate per hour |
|---|---|---|---|
| 0817½ - 0827½ | Thos. R. Turman | 54 | 324 |
| 0830 - 0840 | " | 72 | 432 |
| 0845 - 0855 | " | 93 | 558 |
| 0905 - 0915 | " | 183 | 1098 |
| 0905 - 0915 | Joe Hildreth (South) | 71 | 426 |
| 0923 - 0933 | " (South) | 173 | 1038 |
| 0913 - 0923 | J. D. Slater (East) | 96 | 576 |

| Time (P.M., C.S.T.) | Observer | No. Meteors | Rate per hour |
|---|---|---|---|
| 0924 - 0934 | J. D. Slater (North) | 234 | 1404 |
| 0723 - 0733 | D. McKnelly | 15 | 90 |
| 0737 - 0747 | " | 14 | 84 |
| 0748 - 0758 | " | 42 | 252 |
| 0800 - 0810 | " | 51 | 306 |
| 0830 - 0840 | " | 51 | 306 |
| 0855 - 0905 | " | 96 | 576 |
| 0907 - 0917 | " | 120 | 720 |
| 0935 - 0945 | " | 257 | 1542 |
| 0949 - 0959 | " | 310 | 1860 |
| 1024 - 1034 | " | 61 | 366 |
| 0840 - 0850 | J. O. Hassler | 67 | 402 |
| 0855 - 0905 | " | 106 | 636 |
| 0907 - 0917 | " | 130 | 780 |
| 0949 - 0959 | " | 294 | 1364 |
| 0913 - 0923 | Bill Simmons (East) | 132 | 792 |
| 0924 - 0934 | " (Rad.) | 229 | 1354 |
| 0817 - 0827 | Robert Sparger | 67 | 402 |
| 0830 - 0840 | " | 74 | 444 |
| 0845 - 0855 | " | 76 | 456 |
| 0905 - 0915 | " | 160 | 960 |
| 0923 - 0933 | " | 268 | 1608 |
| 0935 - 0945 | " | 375 | 2250 |
| 0949 - 0959 | " | 475 | 2850 |
| 0923 - 0933 | Leigh Ortenburger | 286 | 1716 |
| 0935 - 0945 | " | 372 | 2232 |
| 0949 - 0959 | " | 433 | 2598 |
| 0923 - 0933 | Lee Tyree | 287 | 1722 |
| 0949 - 0959 | " | 454 | 2724 |
| 0828 - 0830 | R. E. Heffner | 50 | 300 |
| 0832 - 0842 | " | 73 | 438 |
| 0850 - 0900 | " | 78 | 468 |
| 0906 - 0916 | B. S. Whitney | 174 | 1044 |
| 0923 - 0933 | " | 282 | 1692 |
| 0935 - 0945 | " | 368 | 2208 |
| 0949 - 0959 | " | 345 | 2070 |
| 1024 - 1034 | " | 81 | 486 |

A long band of cirro-stratus 3° wide passed over the radiant at about 0930. Cloudiness increased until end of observing period, when the sky was nearly half-covered with cirro-stratus. It is estimated that counts at the end of the period should be increased by a factor of not more than 2, to allow for the increase in cloudiness.

I may add that, possibly due to moonlight, few people reported long-enduring or drifting trains. Nevertheless, there were some, and further data are being sought on them. One report from a member in Alaska and one from a man in Venezuela are the only two so far from outside the country. Not until the European reports are available will we be able to fix when the shower began. The American reports show its maximum, and we conclude that it ended rather abruptly, unless indeed observers in the Pacific or Asia send in information which will force us to revise our opinions.

Flower Observatory, Upper Darby, Pa., 1946 October 22.

# Contributions of the Society for Research on Meteorites

*Edited by* FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

## Report of the Ninth Meeting of the Society

JOHN A. RUSSELL, *Acting Secretary for the Meeting*
Department of Astronomy, University of Southern California, Los Angeles

The Ninth Meeting of the Society was held in Flagstaff and at Meteorite Crater, near Canyon Diablo, Arizona, on September 9 and 10, 1946, the President of the Society, Dr. Lincoln La Paz, presiding. Since the Secretary, Dr. C. H. Cleminshaw, was unable to be present, Dr. John A. Russell was appointed by the President to serve during the meeting as Acting Secretary. When the President delivered a paper, the chair, at his request, was occupied by the Editor, Dr. Frederick C. Leonard.

The following 26 members were in attendance at one or more of the sessions of the Society, of which all were open to the public and at which a considerable number of guests likewise were present: Daniel P. Barcroft (Madera, California), Brandon Barringer (Philadelphia, Pennsylvania), Richard W. Barringer (Philadelphia, Pennsylvania), Mrs. Sonia Barringer (Philadelphia, Pennsylvania), Walter W. Bradley (San Francisco, California), L. F. Brady (Flagstaff, Arizona), John Davis Buddhue (Pasadena, California), Robert L. Darneal (San Francisco, California), Walter H. Haas (Albuquerque, New Mexico), Arthur S. King (Pasadena, California), Carl O. Lampland (Flagstaff, Arizona), Miss Leota Jean La Paz (Albuquerque, New Mexico), Lincoln La Paz (Albuquerque, New Mexico), Frederick C. Leonard (Los Angeles, California), P. J. McGough (Flagstaff, Arizona), Oscar E. Monnig (Fort Worth, Texas), G. E. Moreton (Los Angeles, California), Archie M. Newton (Los Angeles, California), Mrs. Addie D. Nininger (Flagstaff, Arizona), H. H. Nininger (Flagstaff, Arizona), Asbjorn P. Ousdal (Santa Barbara, California), William A. Rhodes (Phoenix, Arizona), Sears P. Roach (Ogden, Utah), Paul E. Roques (Los Angeles, California), John A. Russell (Los Angeles, California), and Walter J. C. Weiss (San Antonio, Texas).

In the morning session of September 10, the President announced that all of the candidates officially nominated for positions in the Council during the 1946-50 term had been elected and that all of the proposed amendments to the Constitution and the Bylaws, circulated with the ballot and with the call for the meeting, had been passed, either unanimously or by a large majority of the votes of some 45 members of the Society. By Art. 1, Sect. 1, of the Constitution, as amended, the name of the Society was accordingly changed, at the adjournment of the meeting, from "The Society for Research on Meteorites" to "The Meteoritical Society."

The number of papers read at the meeting was 24, of which 20 were read in full and 4 by title, and of which all but 2 were presented personally by their authors. Lively discussion followed the reading of nearly every paper on the program, and, only because of lack of time, did 4 of the papers have to be presented merely by title. Following is the list of the papers delivered at the meeting.

LIST OF PAPERS READ AT THE NINTH MEETING

The papers are numbered in the order in which they were read. Papers marked by a star (*) were presented personally by their authors; those marked by a dagger (†) were read by title only.

*Morning Session, September 9*

*1. "The Specific Gravity of Meteoritic Iron," Mr. John Davis Buddhue, 99 South Raymond Avenue, Pasadena, California. (Read, at the author's request, by Dr. Frederick C. Leonard.)

*2. "Similarity of the Living Form Calothrix Parietina (Noeg. Thuret) Apparently Identical with Specimens Found in a Stone Meteorite," Dr. Asbjorn P. Ousdal, Research Associate, University of Southern California, Los Angeles.

3. "Hypothetical Meteorites of Sedimentary Origin," Mr. Frank C. Cross, 9413 Second Avenue, Silver Spring, Maryland. (Read by Dr. Leonard.)

*4. "A Preliminary Report on the Fall of the Pena Blanca Springs, Brewster County, Texas, Aerolite," Mr. Oscar E. Monnig, 1010 Morningside Drive, Fort Worth, Texas.

*5. "The Giacobinid Meteors," Dr. Lincoln La Paz, Institute of Meteoritics, University of New Mexico, Albuquerque.

*Afternoon Session, September 9*

*6. "Oxidized Meteorites," Dr. H. H. Nininger, American Meteorite Laboratory, P.O.B. 32, Flagstaff, Arizona.

*7. "An Investigation of the Time Distribution of Meteoritic Falls by Years," Dr. John A. Russell, Department of Astronomy, University of Southern California, Los Angeles.

*8. "The Effect of the Earth's Magnetic Field upon Iron Meteorites Passing thru it," Mr. William A. Rhodes, 4337 North 14th Street, Phoenix, Arizona.

*†9. "A Catalog of Provisional Coördinate Numbers for the Meteoritic Falls of the World," Dr. Frederick C. Leonard, Department of Astronomy, University of California, Los Angeles.

*10. "Desiderata for a General or Comprehensive Catalog of the Meteoritic Falls of the World," Dr. Frederick C. Leonard.

*Morning Session, September 10*

*11. "An Aerolite from Allen, Collin County, Texas," Mr. Oscar E. Monnig.

*12. "Further Notes on the Puente-Ladron, New Mexico, Aerolite," Dr. H. H. Nininger.

*13. "On the Lunar Atmosphere," Dr. Lincoln La Paz.

*†14. "Contraterrene Meteorites," Dr. Linclon La Paz.

*15. "A Report on a Search for Possible Lunar Meteoric Phenomena," Mr. Walter H. Haas, Institute of Meteoritics, University of New Mexico, Albuquerque.

*16. "The Coördinate Numbers of the Falls of the U.S.S.R., Estonia, Latvia, Lithuania, and Poland," Dr. Frederick C. Leonard.

*17. "A Cosmic Bomb Destroys a Civilization," Mr. Archie M. Newton, Griffith Observatory, Los Angeles, California.

18. "The Probability of Coincidental Meteoritic Falls," Dr. Paul G. Hoel, Department of Mathematics, University of California, Los Angeles (introduced by Frederick C. Leonard). (Read, at Dr. Leonard's request, by Dr. La Paz.)

*19. "Observations on the Carolina Bays," by Brandon Barringer, The Pennsylvania Company, Chestnut Street, Philadelphia, Pennsylvania. (Read, at the author's request, by Dr. Nininger.)

*20. "A Possible Meteorite Crater in the Aleutians," Dr. Lincoln La Paz.

*†21. "The Barringer Meteorite Crater," Dr. H. H. Nininger.

*22. "Adventures in a Magnetic Search for Meteorites," Dr. H. H. Nininger.

*†23. "Meteorite Collectors Employing Portable 4900-gauss Permanent Magnets," Dr. Lincoln La Paz.

*Afternoon Session, September 10 (at Meteorite Crater)*

*24. "The Report of the President of the Society for the Term 1941 June to 1946 September," Dr. Lincoln La Paz. [Adjournment, *sine die.*]

The morning and afternoon sessions of September 9 and the morning session of September 10 were, thru the courtesy of President Tom O. Bellwood, held in the Science Hall of the Arizona State College at Flagstaff, while the afternoon session of September 10 was held within the north-northwestern part, near the top of the rim, of Meteorite Crater.

A meeting of the Council, at which President L. La Paz, Treasurer L. F. Brady, Editor F. C. Leonard, and Councilor O. E. Monnig were present, and at which Dr. J. A. Russell served as Acting Secretary, was held at the College just before the afternoon session of the Society was called to order on September 9.

At the kindly invitation of Director Harold S. Colton of the Museum of Northern Arizona, the members and guests of the Society attended a picnic supper at the Museum immediately after the adjournment of the afternoon session on September 9.

Thru the courtesy of Dr. Carl O. Lampland, the library and the 24-inch refractor of the Lowell Observatory were made available to members of the Society and their friends during the evening of September 9.

Refreshments were generously provided at the Crater by Mr. and Mrs. Brandon Barringer and Mr. Richard W. Barringer for all those who made the excursion to the Crater on the afternoon of September 10.

Treasurer Brady served as the very efficient and genial Chairman of the informal Committee on Arrangements for the Ninth Meeting, which consisted theoretically of all the members of the Society resident in and near Flagstaff. The thanks of those present at the meeting were expressed to President Bellwood of the College, Director Colton of the Museum, and Treasurer Brady of the Society for their respective parts in making the meeting both a pleasurable occasion and a success.

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## Amendments to the Constitution and the Bylaws of the Society Adopted at the Ninth Meeting, 1946

[The following amendments to the Constitution and the Bylaws of the Society (*v. C.S.R.M.*, **2**, 322-9, 1941) were adopted at the Ninth Meeting of the Society, held at Flagstaff and Meteorite Crater, Arizona, on 1946 September 9 and 10, and became effective upon the adjournment of that meeting.—Ed.]

### (1) AMENDMENTS TO THE CONSTITUTION

ARTICLE 1—NAME, PURPOSE, AND SCOPE

Sect. 1. The name of this Society shall be THE METEORITICAL SOCIETY.

Sect. 2. The purpose of this Society shall be to promote the discovery, collection, investigation, and preservation of meteorites; to forward the observation and study of meteors and other meteoritical phenomena; and generally to advance meteoritics and related sciences thru the increase and diffusion of knowledge concerning meteorites and meteors.

ARTICLE 3—COUNCIL (OFFICERS AND COUNCILORS)

Sect. 1: Change "and an Editor" to "an Editor, and a Director of the Meteor Section."

Sect. 2: Change the 2nd sentence to read thus: "The Councilors shall include, *ex officio,* the most recent Ex-President, during the term next following that in which he was President, provided he finished the latter as President and is not serving currently as an Officer, and, exclusive of him, shall be equal in number to the Officers."

Sect. 3: Add to the 1st sentence the following clause: "of which the date shall be fixed by the Council and announced to the Society at least 4 months in advance."

Sect. 5: Combine the 2nd sentence with the 1st, making the former read thus: "but the number of the elective positions in the Council shall remain unchanged thruout a term."

Sect. 6. No person shall hold simultaneously more than one position in the Council, in which the President, however, shall have both a regular and a casting vote.

Sect. 7: Add to the 1st sentence: "and no person who has served as President shall be eligible to serve as a Vice-President in the next following term."

ARTICLE 4—PUBLICATIONS

Sect. 1. The Society, thru its Council, shall either establish and maintain its own publications, or designate and employ one or more of the scientific serials of good reputation and wide circulation as its official journal or journals.

ARTICLE 5—METEOR SECTION (a *New* Article)

Sect. 1. The Meteor Section of the Society shall specialize in the observation and study of meteors; it shall be open to every member of the Society in good standing who is interested in doing that kind of work; and it shall consist of all such members who have joined it.

Sect. 2. The Meteor Section shall be under the management of the Director of the Meteor Section, who must be a member of the Section.

ARTICLE 5—AMENDMENTS AND BYLAWS TO BE *Renumbered* AS ARTICLE 6

(2) AMENDMENTS TO THE BYLAWS

ARTICLE 3—APPOINTMENTS AND DUTIES OF APPOINTEES

Sect. 3. Some member of the Council who is also a Fellow of the American Association for the Advancement of Science shall be appointed by the Council, at its first meeting in each term, for the duration thereof, as the Representative of the Society in the Council of the American Association for the Advancement of Science.

THREE *New* SECTIONS, TO BE ADDED TO THIS ARTICLE, AS FOLLOWS:

Sect. 5. The following standing committees of the Society, each of which shall consist ordinarily of not less than 3, or more than 7, members, and include

the President as an *ex-officio* member, shall be appointed by the Council at its first meeting in each term, or as soon thereafter as possible, for the duration of the term: (1) the Committee on Membership and Fellowship, of which the Secretary also shall be an *ex-officio* member; (2) the Committee on Finance and Endowment, of which the Treasurer also shall be an *ex-officio* member; and (3) the Committee on Publications, of which the Editor also shall be an *ex-officio* member.

Sect. 6. Any appointments, not otherwise provided for in these Bylaws, shall be made by the Council, or, when it is not in session, by its Executive Committee or the President.

Sect. 7. Any vacancy in the appointive positions of the Society, made for the duration of a term, shall be filled by the Council, or, when it is not in session, by its Executive Committee, for the remainder of the term.

ARTICLE 4—FINANCE

Sect. 1. The entrance fee to the Society of each person elected for the first time as a member thereof shall be two dollars ($2.00), payable to the Treasurer on the date of election.

ARTICLE 6—MEETINGS OF THE COUNCIL

Sect. 1. A meeting of the Council shall be held in connection with each meeting of the Society and also immediately after the adjournment of each electoral meeting, at the place of the electoral meeting.

ARTICLE 8—AMENDMENTS: "Article 5" read "Article 6."

## The Effect of the Earth's Magnetic Field upon Iron Meteorites Passing thru it*

WILLIAM A. RHODES
4337 North 14th Street, Phoenix, Arizona

Following is a possible explanation of why some meteorites are allegedly found hot and others cold, upon their arrival at the Earth's surface.

In the laboratory, an experiment was set up to simulate the flight of a nickel-iron meteorite thru a cross-section of the Earth's magnetic field and at right angles to the lines of that field. The testing unit was constructed in such a way as to cause a continuous and non-fluctuating magnetic field to cut thru a small nickel-iron specimen. The number of magnetic lines of force of the field over a given area and the speed at which the field cut thru the specimen were adjusted so as to produce the approximate conditions of an iron meteorite traveling at the slow rate of one mile per second and approaching the Earth at the equator at right angles to its magnetic axis. The temperature of the specimen before entry into the magnetic field was +80° F.; the temperature after a hypothetical flight of 60 seconds in the field was +378° F., thus representing a gain of 298° F.

It is quite obvious that any iron meteorite traveling *parallel* to the lines of force would not derive any heat. It is obvious also that a stony meteorite would not be affected by the lines of force, regardless of the angle at which it cut thru them; therefore, according to this hypothesis, the meteorite might be found cold immediately upon its arrival at the Earth's surface.

*Read at the Ninth Meeting of the Society, Flagstaff and Meteorite Crater, Arizona, 1946 September 9 and 10.

The foregoing explanation should be considered in no way conclusive, as the experiment was set up and performed in haste, and the depth and density of the Earth's field at the equator could be only guessed at. The drag produced is considerable upon the specimen, and it can readily be seen that, even tho the magnetic field be weak, the high speeds of some meteorites cutting an enormous number of lines of force over a short period of time would produce plenty of heat by inductance.

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### A Preliminary Report on the Fall of the Pena Blanca Springs, Brewster County, Texas, Aerolite (1031,301)* (Abstract)

Oscar E. Monnig
1010 Morningside Drive, Fort Worth 3, Texas

A single, achondritic aerolite, exceeding 155 pounds in weight, fell on 1946 August 2, about 1:15 P.M., C.S.T., into a pool of the Pena Blanca River, near Marathon, Brewster County, Texas. It broke into pieces of 104 and 29 pounds, and smaller ones. The remarkable circumstances of the fall and the recovery are related, including the splashing of water onto the truck of two passers-by and the witnessing of the falling rock from a nearby house. Detonations were well heard, but only one, somewhat doubtful observation of the meteor and the dust cloud has been found. The evidence indicated that the meteorite came from the south and west and fell probably at a fairly steep slope; it was not related to the meteor showers then active. The stone is thinly crusted, with a grayish to cream-colored, melted surface, and has an essentially whitish interior with some very coarse crystals. It is an unusual type of aerolite and the largest witnessed fall to date in Texas. The coördinate number of the fall is 1031,301.

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### An Aerolite from Allen, Collin County, Texas* (Abstract)

Oscar E. Monnig
1010 Morningside Drive, Fort Worth 3, Texas

A description of the circumstances involved in the finding (1923) and the identification (1938) of an aerolite from near Allen, Collin County, Texas (coördinate number = 0967,331), is given. The stone is an essentially complete individual of 1409 grams (a little over 3 pounds), with a dominant exterior color of dark gray, looking like a relatively recent fall; yet it is known to have been outdoors most of the time from the date it was picked up until its identification, and has travertine deposits on what were presumably buried areas of the surface. The point of find is about 6 miles from that of the McKinney, Collin County, Texas, stones (C.N. = 0966,332; cl. = black chondrite, Cs), but the Allen find is differentiated from these. It is definitely a chondrite and is classified tentatively as a veined crystalline chondrite, Cka. It is moderately metal-rich, from macroscopic examination and a check with an alnico magnet.

*Read at the Ninth Meeting.

### A Cosmic Bomb Destroys a Civilization* (Abstract)

ARCHIE M. NEWTON
Griffith Observatory, Los Angeles, California

The hypothesis is presented that the destruction of the civilization known as the "Cliff Dwellers" was caused by the fall of the great meteorite that excavated the so-called Barringer Crater, near Canyon Diablo, Arizona.

### Appointments for the 1946-50 Term

The following appointments for the 1946-50 term were made by the Council of the Society at its first meeting of the term held in Flagstaff, Arizona, on 1946 September 11. Present at this meeting were President A. S. King, Secretary O. E. Monnig, Treasurer L. F. Brady, Editor F. C. Leonard, Councilor (Ex-President) L. La Paz, and Councilor J. D. Buddhue.

In accordance with Art. 3, Sect. 5, of the Bylaws, the following standing committees of the Society were appointed:

(1) *Membership and Fellowship:* Secretary O. E. Monnig *(ex officio)*, Chairman; L. F. Brady (subsequently added by the Executive Committee of the Council), J. D. Buddhue, President A. S. King *(ex officio)*, H. H. Nininger, J. H. Pruett, R. W. Webb, and F. L. Whipple.

(2) *Finance and Endowment:* Treasurer L. F. Brady *(ex officio)*, Chairman; D. M. Barringer, Jr., J. Kaplan (added by the Executive Committee), President A. S. King *(ex officio)*, and P. J. McGough.

(3) *Publications:* Editor F. C. Leonard *(ex officio)*, Chairman; C. H. Gingrich, President A. S. King *(ex officio)*, L. La Paz, and J. A. Russell.

Councilor L. La Paz was re-appointed as the *Representative of the Society in the Council of the American Association for the Advancement of Science.*

A special *Committee on the Revision of the Articles of Incorporation*, consisting of F. C. Leonard as Chairman and N. Schwartz, also was appointed.

Dr. Joseph Kaplan of the University of California, Los Angeles, was appointed a *Councilor of the Society*, in anticipation of the appointment of a Director of the Meteor Section, who is yet to be appointed. (According to Art. 3, Sect. 2, of the Constitution, the Councilors, exclusive of the most recent Ex-President, "shall be equal in number to the Officers," of whom the Director of the Meteor Section will be one; hence the appointment of an additional Councilor.)

OSCAR E. MONNIG, *Secretary*

1946 September 27

*President of the Society:* ARTHUR S. KING, Mount Wilson Observatory, Pasadena 4, California
*Secretary of the Society:* OSCAR E. MONNIG, 1010 Morningside Drive, Fort Worth 3, Texas

### Spectacular Shower of Meteors Observed in Berea, Kentucky

On the night of October 9, 1946, a shower of meteors greeted Bereans the like of which few have ever seen before. Although predicted to be the evidence of the comet Giacobini-Zinner which makes frequent journeys around the sun, this display proved to be better than local astronomers had really expected.

*Read at the Ninth Meeting.

Residents of the Isle of Malta are reported to have seen a display in 1933 which averaged over four thousand meteors per hour from this same comet. The display at Berea was about half as good in 1946. A group of observers on Peach Bloom Hill did observe one thousand meteors within a short space of thirty minutes. This would make about 2000 per hour in Berea as compared to four thousand at Malta in 1933.

Our observations began at 9:25 P.M. just as the northwest sky was being cleared of clouds. Many of these fiery bodies seemed to almost blot themselves out as they hid behind the clouds they approached from the radiant point. By 9:55 P.M. our group of eight observers had counted a thousand trails of fire seen during those thirty minutes. The average of thirty-three "shooting stars" a minute is an experience long to be remembered and possibly never to be duplicated again in one's life time.

During the early part of our half-hour period of counting meteors the average per minute seems to cluster around 15. This grew in number until the number seemed to average around forty per minute by 9:50, making the average of 33 when the half hour was over.

While some of the meteors had brilliancies comparable to those of Venus or Jupiter, it was noticeable that none seemed to last more than three or four seconds on their journey. They were then burned out and were ready to float to the earth in ashes. The full moon obscured possibly half of the actual meteors because of the intense light it was giving in competition to these small visitors in the northwest. Thus it seems easily probable that Berea was treated to as grand a show as was Malta, some thirteen years ago.

These little specks of sand that burned up in the sky before our very eyes seemed to originate about half way between the bright star Vega and the well known north pole star Polaris, somewhere in the constellation Draco. Of course many were not seen in this neighborhood of the sky, but were caught by the eye some ninety or more degrees away.

The observers Dr. and Mrs. Feaster Wolford, Miss Mildred Miller, Miss Eleanor Brooks, Sarah Ann, Martha Lou, and William Hutcherson, Jr., and Mr. and Mrs. W. R. Hutcherson were counting about as fast as they could count. About 10:20 P.M. the display seemed to quiet down and the sky resumed its normal quiet state.

W. R. HUTCHERSON.

Berea, Kentucky, October 10, 1946.

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**The Meteors of October 9, 1946, at the Washburn Observatory**

The sky at Madison, Wis., was cloudy in the early evening of October 9 but began clearing shortly after 8 P.M. local time. A number of members of the Madison Astronomical Society were on hand as the clouds broke, but it was more than an hour before we got organized for systematic counting. One group of four observers could cover about three-fourths of the sky, omitting the area around the moon. A second group had three observers and a timer. The third group of only two, some fifty yards away, seemed to get more meteors than the others. In each group the observers kept close together, counting out loud to avoid duplication. There were occasional breaks to interchange observers, but the conditions in each group were practically the same throughout the evening. The groups worked independently and the times were not always synchronous. The

night was hazy with a bright full moon, and of course many fainter meteors were missed. There were a few passing clouds which did not interfere with the observations, but after about 5:10 G.C.T. clouds came over to stay for the remainder of the night. The table gives a summary of the counts by five-minute intervals.

The most striking feature of the shower was the sharp maximum at about 3:50 G.C.T. certainly after 3:45 and before 4:00, as shown by all records. We made no effort to estimate how many meteors could be seen by a single observer, but at the maximum a group of several persons could count at the rate of about 300 in five minutes or 1 per second or, say, 3,000 to 4,000 per hour.

The meteors were slow, many leaving trails. Their color was mostly yellow rather than white. The faintest were third to fourth magnitude. There were many first magnitude and brighter, and three or four were far brighter than Venus, approaching the crescent moon. Several of these bright ones left trails which persisted for one or two minutes. A few meteors near the radiant came apparently "head on." Naturally nobody present had ever seen anything like this shower, and the feeling was that if the moon had been absent a far greater number would have been counted.

E. P. Bailey
C. M. Huffer
L. W. Ketchum
J. Stebbins

O. J. Eggen (Timer)
R. Jalson
J. W. Larson
E. E. Miller

L. Averill
Mrs. L. Averill
. . . . . .
. . . . . .

| GCT | No. | GCT | No. | GCT | No. |
|---|---|---|---|---|---|
| | | $2^h$ - $3^h$ | 250/hr | h m h m | |
| . . . . . | | . . . . . | | 2:31 - 3:06 | 100+ |
| . . . . . | | . . . . . | | 3:06 - 3:11 | 35 |
| . . . . . | | . . . . . | | 3:11 - 3:16 | 80 |
| . . . . . | | h m h m | | 3:16 - 3:21 | 78 |
| h m h m | | 3:20 - 3:25 | 108 | 3:21 - 3:26 | 84 |
| 3:24 - 3:29 | 85 | . . . . . | | 3:26 - 3:31 | 76 |
| 3:30 - 3:35 | 108 | 3:30 - 3:35 | 141 | 3:31 - 3:36 | 150 |
| 3:35 - 3:40 | 142 | . . . . . | | 3:36 - 3:41 | 140 |
| 3:40 - 3:45 | 149 | 3:40 - 3:45 | 277 | 3:41 - 3:46 | 275 |
| 3:48 - 3:53 | 252 | . . . . . | | 3:46 - 3:51 | 290 |
| . . . . . | | . . . . . | | 3:51 - 3:56 | 305 |
| 3:55 - 4:00 | 194 | 3:55 - 4:00 | 324 | 3:56 - 4:01 | 200 |
| 4:01 - 4:06 | 159 | 4:00 - 4:05 | 197 | 4:01 - 4:06 | 167 |
| 4:06 - 4:11 | 114 | . . . . . | | . . . . . | |
| 4:13 - 4:18 | 95 | . . . . . | | . . . . . | |
| 4:20 - 4:25 | 72 | . . . . . | | . . . . . | |
| 4:30 - 4:35 | 49 | . . . . . | | . . . . . | |
| 4:45 - 4:50 | 40 | . . . . . | | . . . . . | |
| 5:00 - 5:05 | 25 | . . . . . | | . . . . . | |

# VARIABLE STARS

## Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

*AAVSO Annual Meeting:* The thirty-fifth Annual Meeting of the AAVSO was held at the Harvard College Observatory on October 11 and 12. Some 50 to 60 members and guests gathered at the business sessions, and at the dinner there

were seventy present.

The Council held two sessions, the first on Friday afternoon and the second Saturday noon. Four life memberships were approved and twenty-five candidates were elected to annual membership, bringing the totals for the year to nine and fifty-three, respectively; a very commendable number.

The question of the Association joining the proposed Amateur Astronomers League was thoroughly discussed and final decision left to a mail vote of the entire membership, the Council having given favorable consideration to the matter.

On Friday evening, the Association acted as host to the Bond Astronomical Club, thus reversing the custom of previous years. Professor George Z. Dimitroff of Dartmouth was the guest speaker, describing in detail, with lantern slides, astronomical conditions in Germany and Japan as he saw them soon after the cessation of hostilities. More than 100 persons filled the lecture hall and renewed acquaintances over refreshments later. For those who were interested in trying their eyes on variable star observing, Secretary Harris acted as demonstrator with the 9-inch Jewett refractor.

At 10:30 Saturday morning the business sessions began, with reports of officers and committees, acceptance of the proposed changes in Constitution and By-Laws, and election of Council members. The names of four members who had died were read, and eulogies were delivered on David B. Pickering and Eugene H. Jones. Counting of the ballots indicated that Mrs. Helen S. Federer had been elected to the Council for another two years; Miss Martha E. Stahr of Wellesley, and Messrs. Paul H. Nadeau of Quebec, Canada, and Theodore R. Treadwell of Arlington, New Jersey, are the new additions to that body.

The report of the Auroral Committee arrived too late to be presented, but it contained a strong plea for more observing, now that aurorae are becoming more frequent as sun-spot maximum approaches.

The Occultation Committee report, presented by the Chairman, Dr. Alice H. Farnsworth, showed continued enthusiasm and much activity among the members.

Probably the most extensive program of endeavor in the extra-curricular field was the report of the Solar Division by Mr. Heines, replete with detailed discussion of the work of its members. This division has a total membership of 74, distributed among 19 states and 6 foreign countries, with 56 active observers. The total number of observations made since the inception of this division two years ago is 11,490. Until July of this year, reports were sent for discussion to the Department of Terrestrial Magnetism of the Carnegie Intitution, and after that date to the United States Bureau of Standards. Besides records of sun-spot numbers, solar granulation and sun-spot colors are being investigated.

Because of the wide distribution of observers, sun-spot data are now available for each day of the year. These data have been supplied not only to the institutions already mentioned, but to a dozen individuals and institutions interested in the material. Migratory Bird Project is being developed in cooperation with the Louisiana State University. This Solar Division well deserves the commendation of the entire association and its future success is well assured.

The report of the Recorder showed a marked increase in the receipt of variable star observations, some of them received from foreign observers and accumulated during the war years. A grand total of 44,272 observations as made by 121 observers was noted, the largest number since the pre-war years. Cyrus F. Fernald of Wilton, Maine, headed the list with 5,016 estimates, followed by Reginald P.

de Kock of Capetown, South Africa, with 4,272. Next came Constantin Chassapis of Athens, Greece, with 2,425—1,073 of these were made during the war. Peltier of Delphos, Ohio, made 2,165 estimates; Luft, then of Sao Paulo, Brazil, 1,983; Holt, of Amherst, Mass., with 1,894; and Hartmann, of St. Albans, New York, with 1,843. The top five observers contributed one-third of all those made, while the top ten made more than half of the whole number. Ten foreign countries, with thirty observers, contributed 17,527 estimates, or 40% of the whole. The grand total of observations contributed since the Association began its task of following some 500 variables, thirty-five years ago, is now about 1,022,500. One of the original observers, Reverend T. C. H. Bouton, of St. Petersburg, Florida, ninety years of age, is still communicating observations, although fewer in number than in earlier years, as is to be expected.

At the adjourned Council meeting, the following officers were elected:

President, Charles H. Smiley
First Vice-President, Marjorie Williams
Second Vice-President, David W. Rosebrugh
Secretary, Herbert M. Harris
Treasurer, Percy W. Witherell
Recorder, Leon Campbell

At the afternoon session, the following papers were presented: *Three Special Variables (Rho Cas, Z And, and XX Oph)*, by Dr. S. Gaposchkin. Particular stress was laid on the recent increase in brightness of Z Andromedae, accompanied by spectral changes.

*Y Ceti*, by Dr. Cecilia Payne-Gaposchkin, in which she showed conclusively that Y Ceti is not a variable, but the result of double field exposures on the original plates.

*Gamma Cassiopeiae*, by H. R. Petzold, in which he thought his own observations indicated a possible 12 to 30 day periodicity.

*Comments on Light Curves*, by Leon Campbell, in which were exhibited the seemingly erratic light curves of R Scuti, extending over the past 13 years, and in which the hope was expressed that some enthusiastic mathematician in the Association would attempt to unravel the periods which seem to work together. Curves of Nova (T) Coronae Borealis and SS Cygni were also shown. Attention was called to the pre-discovery photographic observation of Nova Puppis, 1942, as noted by Dr. S. Gaposchkin on a Harvard plate taken some five hours earlier than Dawson's first glimpse of the star.

*Miscellany*, by David W. Rosebrugh, in which he described at length his numerous gadgets and special eyepieces, his work on sun-spot colors, and solar granulation.

*Detecting Sun-Spots at Night*, by H. B. Chase, in which he depends on radio disturbances to note the presence of sun-spots even though they cannot actually be seen.

*Color in the Granulated Sun*, by J. C. Bartlett, Jr., giving a further exposition of the results obtained by several solar observers interested in this special feature.

*A Sun Pillar of 1943*, by Neal J. Heines, in which he describes a remarkable atmospheric phenomenon observed before sunrise in that year.

*King's Sidereal Time Gadget*, by Morgan Cilley (read by title) a device for quickly determining sidereal time at any station.

After adjournment of the afternoon session, tea was served by the Observatory staff.

In the evening, the group gathered at the Harvard Faculty Club for the annual dinner, which consisted of melon, chicken, vegetable, rolls *without* butter, ice cream and coffee. President Smiley acted as Toastmaster, first introducing Mr. James S. Pickering, who spoke of his pleasure at attending his first AAVSO meeting. The three members present who had attained a place on the AAVSO Honor Roll for having contributed 10,000 or more observations, also spoke. These were Messrs. Holt, Rosebrugh, and Fernald. The Honor Roll contained the names of 25 persons, including one woman, Mrs. Winifred Kearons. Charles A. Federer gave an animated account of the Harvard Up-in-the-Air trips to observe the Draconids of October 8 and 9. The *pièce de résistance* was Dr. Shapley's "Some Highlights of Astronomy during 1946." These included:

1. The recent Draconid Meteor Shower, which produced the finest display of the present century—where clouds did not interfere—and which marked an achievement in accurate timing of the event, as computed by Dr. Leland E. Cunningham.

2. The appearance of two more recurrent novae, Nova (T) Coronae Borealis and Nova Sagittae 1913, thus increasing to six the number of known novae of this type.

3. The observational work of Dr. A. E. Whitford, whereby he was able to measure diameters of stars with the aid of the Moon—probably the outstanding achievement of the year.

4. Bouncing of Radar back from the Moon, the beginning of *possible* interplanetary communication in the future.

5. Stratospheric rockets projected 100 miles into the atmosphere, resulting in discoveries of greater frequencies of cosmic ray showers, and encouraging establishment of more cosmic ray stations.

6. The Detroit Meeting of representatives from American amateur groups, leading to a possible new national astronomical society—to be known as the A.A.L., the Amateur Astronomers League.

7. Plans for the establishment of high altitude stations, such as the joint project at Climax, Colorado, between the University of Colorado and Harvard University, with new and better coronagraphs and meteor cameras to study relations between solar and terrestrial phenomena.

8. The joint Irish-American station in South Africa, with an improved Baker-Schmidt telescope.

Concluding the evening session was *Who's Who on the Honor Roll*, by the Recorder, who gave thumbnail sketches of the 25 persons listed on the roll.

The meeting adjourned at 9:30 o'clock, to meet in the spring at a time and place yet to be selected. Suggestions welcomed!

*Observations received during September:* A total of 3,806 observations were received in September from 58 observers, as follows:

| Observer | No. Var. | No. Ests. | Observer | No. Var. | No. Ests. |
|---|---|---|---|---|---|
| Ahnert | 28 | 169 | Bouton | 2 | 2 |
| Ball | 15 | 15 | Buckstaff | 19 | 66 |
| Blunck | 51 | 58 | Buscombe | 13 | 13 |
| Bogard | 1 | 1 | Chabot | 5 | 17 |
| Boone | 15 | 15 | Cilley | 12 | 24 |

| Observer | No. Var. | No. Ests. | Observer | No. Var. | No. Ests. |
|---|---|---|---|---|---|
| Dafter | 6 | 16 | Mary | 23 | 23 |
| Fernald | 232 | 398 | Nadeau | 107 | 138 |
| Flower | 4 | 17 | Oheim | 107 | 150 |
| Garneau | 17 | 17 | Oravec | 48 | 115 |
| Greenley | 8 | 8 | Parks | 25 | 46 |
| Guimont | 3 | 3 | Peltier | 180 | 301 |
| Halbach | 42 | 43 | Petzold, H. R. | 50 | 379 |
| Hare | 24 | 58 | Pilsworth | 7 | 7 |
| Harris | 26 | 26 | Raphael | 22 | 179 |
| Hartmann | 144 | 168 | Rayna | 13 | 42 |
| Holloway | 10 | 17 | Reeves | 2 | 4 |
| Holt | 110 | 164 | Renner | 75 | 90 |
| Howarth | 13 | 13 | Rosebrugh | 10 | 116 |
| Hukill | 3 | 50 | Seagraves | 4 | 9 |
| Kearons | 31 | 33 | Schoenke | 18 | 24 |
| Kelley, M. | 5 | 14 | Stahr | 10 | 11 |
| Kelly | 11 | 16 | Upjohn | 3 | 6 |
| Kitley | 38 | 87 | Wade | 6 | 41 |
| Knott | 1 | 3 | Webb | 30 | 36 |
| de Kock | 97 | 384 | Weber | 28 | 28 |
| Kohn | 7 | 20 | Welker | 28 | 38 |
| Koons | 61 | 73 | Welles | 5 | 13 |
| Labrecque | 1 | 18 | Zirin | 41 | 48 |
| Luft | 3 | 6 | — | | — |
| Mallett | 30 | 30 | 58 | totals | 3,806 |

October 17, 1946.

# Comet Notes

By G. VAN BIESBROECK

The expected meteor shower resulting from the close approach of the earth to the path of the periodic COMET GIACOBINI-ZINNER has proved to come up to expectations. However, only short radio reports are available at this time. On October 9 clouds covered most of the eastern part of the country; in the middle west a good many meteors were seen but often through haze and clouds; complete records are awaited from the western section of the country where the observers called the shower the most striking astronomical phenomenon of the century. The comet which caused this meteoric display is moving rapidly southward and gradually fading; by the end of this month it will no longer be in reach of northern observers but it will remain observable for quite a while on the other side of the equator.

No other known comets are now in reach of medium-sized instruments. Larger telescopes are required to follow the fading comets TIMMERS, periodic BROOKS, and TEMPEL II.

COMET JONES whose discovery was reported last month is not expected to come in view before next January for northern observers.

The field of periodic comet SCHWASSMANN-WACHMANN was scanned by the writer several times but this elusive object was not seen near the ephemeris position given last month on p. 421.

The ephemeris is continued here:

| 1946 | $\alpha$ h m | $\delta$ ° ′ |
|---|---|---|
| Nov. 4 | 6 51.3 | +30 41 |
| 12 | 50.0 | 47 |
| 20 | 48.0 | 54 |
| 28 | 45.4 | 59 |
| Dec. 6 | 43.3 | 31 4 |
| 14 | 38.7 | 8 |
| 22 | 34.7 | 10 |
| 30 | 6 30.7 | +31 11 |

From previous experience it is known that this comet varies enormously in brightness and can be expected to flare up any time. Hence it is very desirable to keep a continuous watch on this object.

Williams Bay, Wisconsin, October 12, 1946.

## General Notes

**Dr. W. Carl Rufus,** Professor Emeritus of Astronomy at the University of Michigan, died on September 21, 1946, at the age of 70 years. Dr. Rufus was Acting Chairman of the Department of Astronomy from 1942 to 1945.

**The Rittenhouse Astronomical Society** held its monthly meeting on October 11, 1946, at the Morgan Physics Laboratory, University of Pennsylvania. The speaker was Dr. John B. Irwin of Flower Observatory, University of Pennsylvania, who spoke on the topic, "Eclipsing Stars."

**J. Peridier,** 16 Rue Cassette, Paris, France, writes that the private astrophysical observatory at Houga (Gers) which began work in 1939 was able to continue its activities throughout the period of German occupation. Indeed, since 1941 some construction has been accomplished and some new departments instituted.

**Mr. Paul E. Wylie, B.S., C.E.,** has been appointed a Lecturer in the Department of Astronomy of the University of California, Los Angeles, for the academic year 1946-47. Mr. Wylie, Dr. Gerard F. W. Mulders of Occidental College, and Mr. Alfred Leonard Buckman, M.A., are all teaching classes in elementary astronomy this year in the University of California Extension Division, either on the Los Angeles campus of the University or at the Extension Division headquarters in downtown Los Angeles.

### The Cleveland Astronomical Society Meeting

The Cleveland Astronomical Society will be twenty-five years old in February, 1947. The Society is sponsoring a fellowship, awarded to a foreign student, to commemorate its Twenty-fifth Anniversary. This fellowship, known as "The Cleveland Astronomical Society Fellowship," has been awarded to Dr. G. B. van Albada. Dr. Albada is a native of Holland and a graduate of the University of Amsterdam. He was introduced to the Society at its first meeting of the season, Friday night, October 11.

The speaker of the evening was Mr. David Dietz, Science Editor of the

Scripps-Howard Newspapers. His topic was "Operation Crossroads." Mr. Dietz gave a vivid description of what he saw and experienced at the Bikini bomb test including his reactions after it was all over.

The speaker then proceeded to what he termed the "Astronomical Overtones." He said the nuclear processes going on in the sun and stars are probably similar but not the same as in the atomic bomb. Some day man may be able to duplicate the processes that give off so much energy from the stars. He asks us not to consider the uranium piles the final word in atomic energy but that energy may be obtained from such a common substance as water in the future. Atomic energy today, says Mr. Dietz, is in the stage where electricity was when Franklin performed his kite experiment. The speaker suggested that a careful study of cosmic rays might lead to important improvements in the work on nuclear fission.

HENRY F. DONNER.

Western Reserve University, Cleveland 6, Ohio.

### Eclipse Plans for May 20, 1947

The National Geographic Society and the Army Air Forces will join in an expedition to the interior of Brazil to observe the total eclipse of the sun on May 20, 1947, it was recently announced by Dr. John Oliver La Gorce, Vice-President of the Society.

Representatives of the two organizations have returned from an advance trip to Brazil, where they consulted Brazilian officials and selected a site for the expedition camp near the town of Bocayuva, about 400 miles north of Rio de Janeiro. Bocayuva, situated on a plateau almost a half mile above sea level, is close to the center of the zone of totality for the eclipse.

The place selected will be an open field on a cattle ranch. There a score of scientists will set up a portable laboratory, transported by air from the United States. They will live in a tent community, managed by the Army Air Forces, while they are awaiting the climactic moment when the moon passes between the earth and the sun.

This site was chosen after AAF observers made aerial photographs and studied weather conditions over a large area along the path of the eclipse. Localities across mountains north of Bocayuva were ruled out because of the prevalence of morning cloud formations, an impediment which the astronomers hope to avoid.

Meteorological information supplied by Brazilian authorities indicates a better than even chance for clear skies during May. The importance of good weather is emphasized by the fact that the period of totality will last for slightly less than four minutes. At Bocayuva it will start about 9:35 A.M.

Dr. Lyman J. Briggs, former director of the National Bureau of Standards and now chairman of the National Geographic Society's research committee, will head the expedition. Participating with the National Geographic Society and the Army Air Forces will be scientists from the National Bureau of Standards, Lick Observatory, Yerkes Observatory, Georgetown Observatory, and the Naval Research Laboratory.

### Amateur Astronomers League

The above title is necessarily new to our readers because the organization itself is new. Since the purposes and projects of a league of amateur astronomers have many points of contact with the wide dissemination of astronomical lore, we

are pleased to bring this new organization to the attention of all who may be concerned.

The Amateur Astronomers League was proposed as a result of the interest manifested in such an organization by those who attended the Fourth Convention of Amateur Astronomers in Detroit on July 5 to 7 of this year. At this Convention a set of by-laws was presented, discussed, and adopted. In the preamble of the by-laws the purposes of the League are stated to be as follows:

(a) To promote the science of astronomy.

(b) To encourage and coordinate activities of amateur astronomical societies.

(c) To foster observation and computational work and craftsmanship opportunities in the various fields of astronomy.

(d) To provide a medium for correlating amateur activities with professional research.

The by-laws provide for three classes of members, namely, Member Organizations, Members-at-Large (individual), Junior Member Organizations.

Article VIII, Section 1, states that these by-laws shall become effective immediately upon the adherence of ten *bona fide* astronomical organizations. Section 2 provides for the setting-up of a temporary council which shall operate until the next National Convention. Section 3 provides for the legal incorporation of the League.

It is suggested that the following form be used by those desiring to become a part of this new national scientific organization:

AMATEUR ASTRONOMERS LEAGUE

RATIFICATION OF BY-LAWS AND APPLICATION FOR MEMBERSHIP

In accordance with the applicable provisions of our own Constitution, By-Laws, or other rules of procedure, the

_____

(Name of Organization)

accepts the By-Laws of the Amateur Astronomers League and hereby applies for membership therein. The initiation fee of three dollars is enclosed.

_____ _____

(Signature) (Title)

_____ _____

(To be signed by appropriate officer or officers)

This form should be forwarded to

James B. Rothschild
P. O. Box 281
Wharton, New Jersey

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**Condition of the Present Sunspot Cycle**

Under the above heading, Mr. Neal J. Heines, Chairman of the Solar Division Committee of the American Association of Variable Star Observers, incor-

porated in his report given at the Meeting of the A.A.V.S.O., held at Harvard College Observatory on October 11, 12, the following paragraphs:

"The Preliminary Relative Sunspot-Numbers of the AAVSO Solar Division continue to show higher values.

"We have received word from Dr. A. Waldmeier, Director of the Federal Observatory of Switzerland concerning his predictions of the coming sunspot maximum. 'Concerning the next sunspot maximum I have recently given a prediction which will appear in *Terrestrial Magnetism:* time of Maximum 1947.6. Largest smoothed monthly relative number 139. We are approaching very quickly a maximum of unusual intensity.'

"This is an earlier date and value than predicted by the American astronomers and research workers with the exception of Dr. John Q. Stewart of Princeton Observatory. During a telephone conversation with your chairman near the end of April, 1946, after being informed by him of existent over-hundred-count days, Dr. Stewart stated that his prediction of 1948.0 as given in your chairman's report of May 1, 1946, would possibly be changed to 1947.8 with a monthly mean over that of the past sunspot cycle.

"The south belt, total group count, for this year is still greater than that of the north belt, but the ratio of increase in the north belt count has changed considerably to date. Up to September 1, 1946, the count was 118 for the north belt and 126 for the south belt. For a comparison, in 1944 the year of the last minimum, the north belt group count was 15 and the south 52. In 1945 there were 57 groups in the north belt and 90 in the south belt. On September 29 there were, to date for 1946, 135 groups in the north belt and 141 in the south belt.

"In the previous cycle, 1933-1944, the total group count for 1937, the year of maximum, was 433 as observed by your chairman. The group count as of September 29, in this the third year of the present cycle is 274.

"In 1936, the year prior to the maximum year, the total group count was 230. This comparison bears out Dr. Waldmeier's statement relative to a 'cycle of unusual intensity.' The date of the coming maximum, however, cannot be definitely ascertained until time has revealed it. We can only estimate trends currently.

"The north belt continues to show the most phenomenal spot-groups. We have again witnessed a phenomenal group during the past summer. On July 19, at 2030 U.T. group number 46192 made its first appearance. Although not as large as 46117 (the January group) it was a very complex disturbance. Drawings of this group were received from Mr. Joseph Swaelen of Antwerp, Belgium, and from Reverend Herbert Kitley of Gosford, Australia. The drawings of both of these gentlemen are most excellent and are on display. Photographs of this group by the Reverend Mr. Kearons have been placed with the drawings for comparison. We are indeed pleased to have these fine observers and delineators in our organization.

"There have been several displays of Aurora Borealis in the lower latitudes during the past summer. This phenomenon is expected to increase in occurrence and intensity during the next few years. One beautiful display in July lasted most of the night and was awe inspiring.

"Disturbance in Radio Communications; Terrestrial magnetism and natural earth currents have increased in proportion to the increase of sunspot and solar activity.

"We are still to witness the most phenomenal effects."

Mr. Heines' complete report comprises twelve typewritten pages. Any observers who wish to become associated with this phase of astronomical work should address inquiries to

Mr. Neal J. Heines,
560 Broadway,
Paterson (4), New Jersey.

## Book Review

**David Rittenhouse,** by Edward Ford. (University of Pennsylvania Press, 1946. Pp. vii & 226. $2.50.)

This volume is one of a series of uniform format entitled Pennsylvania Lives. Another Life in the series, of especial interest to astronomical readers, is that of J. A. Brashear. Rittenhouse was a true Pennsylvanian, as he was born in this state, never lived elsewhere, and died here. Many of his activities relate to this state. His name is very familiar to Philadelphians, if for no other reason than that it has been assigned to public places. Readers of this magazine should be familiar with the Rittenhouse Astronomical Society.

Rittenhouse is classed as an astronomer, but the headings of some of the chapters of this biography indicate his varied occupations—I do not write interests for he was not always deeply interested in his occupations—Clockmaker; Provincial Surveyor; Solar System in Brass (orreries); Astronomer; War Clouds; Treasurer in Exile; Optics and Magnetism; Mathematician to Jefferson; Mint Builder; Return to Science.

We read with regret how this man with great research ability and keen desire to use it was unable to do so during so much of his life because of the necessity of making his living. He performed many public functions which could have been carried out by others equally well, if not better, a condition recognized and lamented by both his contemporary friends and enemies. Some fruitless efforts were made to correct it. He held the title Professor of Astronomy at the University of Pennsylvania from 1779 to 1782, at a salary of three hundred pounds per year. But he had not the qualifications of a good teacher, in fact disliked teaching, so the appointment meant little. He had a weak voice and was a poor speaker. He also served the University as Trustee and Vice-provost.

Such a varied career involves many difficulties for a biographer. The only other important record of his life is one by Rittenhouse's nephew, published in 1813. Such a close relationship has both advantages and disadvantages for a biographer. Another, written by the late Dr. Maurice J. Babb, has not been published. The present biographer views the life and its results farther removed from the events and is not under the temptation to omit unfavorable material as a nephew might be.

The book presents the story of a very interesting life. It is well written and is printed in attractive form. At the end it gives a useful bibliography of the original sources. The book seems to be accurate on the whole but some errors have been noted. I mention a few, restricting myself to points of astronomy. The publishers have been notified of minor typographical errors.

P. 36 No parallax was derived from the transit of 1639. The accepted value was based on observations on Mars and was more than a guess. P. 38.

The twenty-four-inch reflector means one of 24 inches focal length, as one would express the size of a telescope in those days, and not one whose mirror was 24 inches in diameter as one would interpret the expression today. Similarly on page 134, where a thirty-six-foot telescope is mentioned as the collimator, the number refers to the focal length. This presumably is the same telescope as that mentioned on p. 38 which had a lens of only 3 inches diameter. Even the great focal length may be very surprising until attention is called to the fact that the method of correcting for chromatic aberration was not discovered until about 1760 and very long telescopes (if refractors) were used to avoid it.

P. 42. The value of the parallax now accepted as the most accurate is 8".790. The "Easy Method" may be interesting but it is not practical. P. 115. I do not accept as facts quite a few of the statements in respect to Herschel and Uranus. See Grant's History of Physical Astronomy, p. 272, *et seq.* P. 134. The sentence beginning 8 lines from the bottom is obscure and needs clarification. P. 188. For the Triangle read Triangulum. P. 203. The statements of the second paragraph are not closely related. Deriving the true from the mean anomaly is not a method of computing an orbit. P. 211. The date of the death should be more explicitly stated. Had more space been used it would have been well to have added some of the opinions on the work of Rittenhouse expressed by his contemporaries, particularly at his death.

SAMUEL G. BARTON.
Flower Astronomical Observatory, University of Pennsylvania, July 19, 1946.

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**Publications Received.**—The publishers of POPULAR ASTRONOMY hereby acknowledge receipt of the following named publications and express their great appreciation of the courtesy shown on the part of those who have sent them.

*Annals of the Dearborn Observatory of Northwestern University:*

Vol. V, Part 1B, Part 3, Part 4. Dearborn Survey of Faint Red Stars, Oliver J. Lee and Thomas J. Bartlett.

*Contributions from the McDonald Observatory:*

No. 81. "Notes on Stellar Spectra," by Otto Struve.

No. 86. "New Orbits for the Spectroscopic Binaries HD 163181 and HD 78316 (76 $\kappa$ Cancri)," by Otto Struve.

No. 87. "The Spectrographic Problem of U Cephei," by Otto Struve.

No. 108. "The Wolf-Rayet Spectroscopic Binaries HD 186943, HD 193928, and HD 211853," by W. A. Hiltner.

No. 109. "The Spectroscopic Orbit of RZ Eridani," by Carlos U. Cesco and Jorge Sahade.

No. 110. "Spectrographic Observations of Thirteen Eclipsing Variables," by Otto Struve.

No. 111. "Spectroscopic Observations of the Eclipsing Variable WX Cephei," by Jorge Sahade and Carlos U. Cesco.

No. 112. "The Velocity-Curves of Seven Cepheid Variables," by Otto Struve.

No. 113. "Curve of Growth for $\delta$ Canis Majoris," by Helen R. Steel.

No. 114. "The Spectroscopic Orbit of TU Monocerotis," by Armin J. Deutsch.

No. 115. "The Spectrum of $\beta$ Coronae Borealis," by W. A. Hiltner.

No. 116. "Spectrographic Observations of the Eclipsing Variables W Ursae Minoris, XZ Sagittarii, and KO Aquilae," by Jorge Sahade.

No. 117. "The Problem of U Coronae Borealis, RS Vulpeculae, and TV Cassiopeiae," by J. Sahade and O. Struve.
No. 118. "The Wolf-Rayet Spectroscopic Binary HD 168206," by W. A. Hiltner.
No. 119. "The Spectroscopic Orbit of the Eclipsing Variable BD+55°616," by Armin J. Deutsch.

*Annals of Harvard College Observatory:*

Vol. 110, No. 7. "Observations of Variable Stars by the American Association of Variable Star Observers," Leon Campbell, Recorder.
Vol. 110, No. 8. "Observations of Variable Stars by the American Association of Variable Star Observers," Leon Campbell, Recorder.

*Harvard Reprints:*

No. 260. "The Milky Way," by Bart J. Bok.
No. 261. "Note on the Discovery of Red Stars," Guillermo Haro.
No. 262. "A Study of the Wolf-Rayet Eclipsing Binary HD 193576 = V 444 Cygni," by Zdenek Kopal.
No. 263. "The Eclipsing Star BD Virginis," by Cecilia Payne Gaposchkin.
No. 264. "Variable Star Notes from the American Association of Variable Star Observers in 1944," by Leon Campbell, Recorder.
No. 265. "The Eclipsing System of RX Cassiopeiae," by Sergei Gaposchkin.
No. 266. "The Wolf-Rayet Eclipsing Variable HV 11086 = HD 214419," by Sergei Gaposchkin.
No. 267. "The Eclipsing Star AR Monocerotis," by Cecilia Payne Gaposchkin.
No. 268. "The Eclipsing System of SX Cassiopeiae," by Sergei Gaposchkin.
No. 269. "Spectrophotometry of Mira Ceti," by Roderic M. Scott.
No. 270. "Eclipses of Stars with Thick Atmospheres," by Cecilia Payne Gaposchkin and Sergei Gaposchkin.
No. 271. "A Preliminary Report on Chromospheric Spicules of Extremely Short Lifetime," by Walter Orr Roberts.
No. 272. "On the Astronomical Dating of the Earth's Crust," by Harlow Shapley.

*Harvard Reprint Series II:*

No. 8. "Edgeless Stars," by Dr. Sergei Gaposchkin.
No. 9. "$\nu$ Sagittarii as a Variable Star," by Dr. Sergei Gaposchkin.
No. 10. "A Study of the Eclipsing Binary U Pegasi, BD+15°4915," by Felix Recillas and Edith Jones Woodward.

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